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Deforestation motivators by small farmers in common and protected lands in South Eastern Nigeria: A Factor Analytic Approach

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Abstract

Study explores through a multivariate analysis the human ecological variables driving deforestation by small farmers in South-eastern Nigeria. Applying frequency scores and factor analytic techniques to data generated from twelve sampled communities in the rainforest of South-eastern Nigeria, through questionnaire and exploratory participatory research methods, it delineates the most significant factors in the decision field of the farmer motivating deforestation. Social psychological factors and preference for virgin forest soils appear to be the most critical of the factors. Strategies to combat deforestation by small farmers may only ignore to their peril these driving forces rooted in the farmer's objective and subjective realities.

Introduction

Local threats to forest in common and protected lands in developing countries are generally well known and attributed to unsustainable exploitation from factors such as agricultural expansion, forest fire, logging, hunting, and the collection of non-timber forest products (Wells & Brandson, 1992). While agricultural expansion by small farmers is the most significant of these proximate factors (CIFOR, 1995; Gardner-Outlaw & Engelman, 1999), accounting for over 60% of tropical forest loss (Sharma, 1992; Vosti, 2001); the above list of direct causes despite their significance particularly when analyzed for sub-national territories, provide little insight in explaining the underlying factors motivating deforestation (Wells & Brandson, 1992; Rudel & Ropper, 1997; Ite, 1997).

Existing studies on the impact of small farmers on deforestation in the West African rainforest regions have implicated several causes ranging from demographic factors, extensive nature of agricultural land use and the frequent cultivation of forest demanding crops (Bisong, 1994; Ite, 1997); to the macro-economic environment signalled by economic crisis and associated correlates such as population growth, increased food crops marketing and modification of farming systems (Mertens, et al, 2000; Mertens & Lambin; 2000). Studies exploring the multivariate factors influencing the decision field of the rural farmers to clear virgin forest rather than use existing farmlands are few (Bisong,

1994). Although the human ecology framework is theoretically postulated to mediate the relationship between humans and their environments through organization, technology, social psychology, population growth, myriads of other socio-economic Variables, and the nature of the environment (Carrey & Schwartzberg, 1969; Browing, 1970; Burton 1983; Bisong, 2001), empirical data specifically delineating human-ecological variables driving deforestation in the context of the objective and subjective realities of rural small holder farmers are non-existent.

Without gain saying, the driving force to deforestation and rural resource exploitation is most often than not rooted in motive (Western, et al, 1994) conditioned by a number of socio-economic and biophysical variables impacting on the decision field of the rural farmer. This paper explores and highlights the multivariate nature of deforestation within common lands and protected areas in order to delineate the most critical variables driving farmer's decision. The study results are likely to be significant in formulating policies to stem deforestation in frontier settlements where agricultural expansion by small farmers are the proximate factors.

The central hypothesis put forward is that "deforestation motivators within the context of rural agricultural systems do not land themselves to single variables, but to a rather broad, complex and over lapping array of variables lodged within farmer's objective and subjective realities that defines the farmer's relationship with the environment. These to a smaller or larger extent include attitudes, perceptions and needs, family size and growth considerations, market Considerations, types of crops grown, nature of the physical environment, resource management know how and a host of other factors.

Human – Ecology and the Deforestation Process

Attempts to understand human diving forces affecting environmental change have been anchored on a number of multivariable models proposed by some environment and development analyst. The popularly known ones are those put forward by (McNamara, 1992), Barry Commoner, (1972) and Grant on behalf of UNICEF (1994) (in Ostrom, 1998).

Barry Commoner's model consist of three casual variables of man-environment interactions given by $I = P \times A \times T$.

where, I = Impact on the environment,

P = Population

A = Affluence (measured by levels of consumption), and

T = Technologies employed.

The UNICEF model is the PPE nexus where poverty and population pressure account for environmental deterioration. McNamara (1992) expressed the relationship between Population and Environmental Conditions as

$$Ed = P \times C \times D$$

where: Ed = Environmental Damage

P = Population

C = Consumption per capita

D = the Environmental Damage per unit of consumption

The models by Commoner and McNamara share a lot in common as they both deal with the influence of population growth and affluence measured by per capita consumption on environmental conditions. They both acknowledge the role of technology in the man – environment relationship explicitly stated by Commoner, but implicitly recognized by McNamara as the damage caused to the environment per unit of consumption, evidently a measure of the sustainability of the technologies employed.

The Commoner – McNamara models are more applicable to the industrialized world as they capture the role of affluence and technology in the environmental deterioration process. The UNICEF model on the other hand deals primarily with developing countries where poverty and population growth are deemed to reinforce one another and jointly impacts on environmental conditions (Ostrom, 1998).

A careful consideration of the two models reveal their inadequacy in providing a robust framework for understanding human – ecological processes driving environmental change either on a global scale or as it applies to rural communities in developing countries.

Human – ecology may be put forward as a more robust framework for understanding the human relationship to the environment and may be useful in explaining human drivers of deforestation. Human ecology captures the various ways humans interact with the environment and the manner in which a population adapts to changes in the environment (Burton, 1983; Glaeser, 1995). This model put together by Browning (1970) conceives human ecology as consisting of four mutually interactive concepts – Technology, Population, Environment and Organization. He posits that technology and organization mediate between population and resources (see Fig 1).

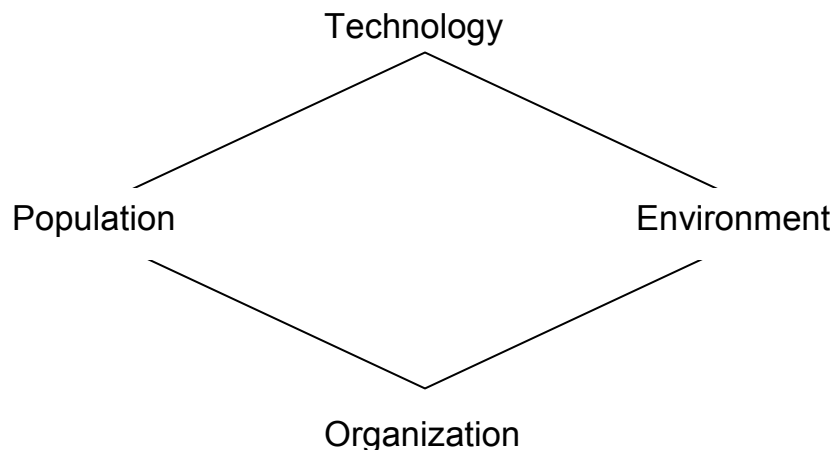


Fig 1 Human ecology after browning, 1970

Carrey and Schwartzberg's conceptualization was more elaborate with a human – ecological model that visualizes a human society living in an environment and that the manner in which a population lives and relates to its environment is a function of its number, growth characteristics, range of choices and potential resources present in the environment, the technology it possesses, the social and production organization and the manner in which the population perceives its environment (Fig 2). (Carrey & Schwartzberg, 1969). The factors of population, environment, technology, organization and social psychology acts iteratively to describe the relationship between the human community and its environment as shown by the connecting lines within the pentagon.

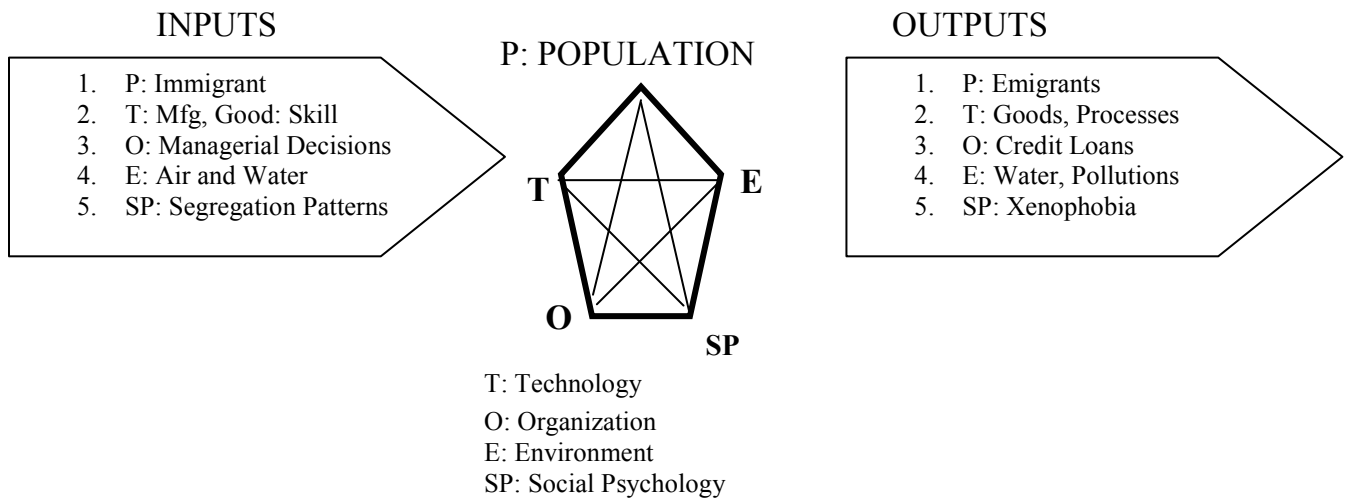


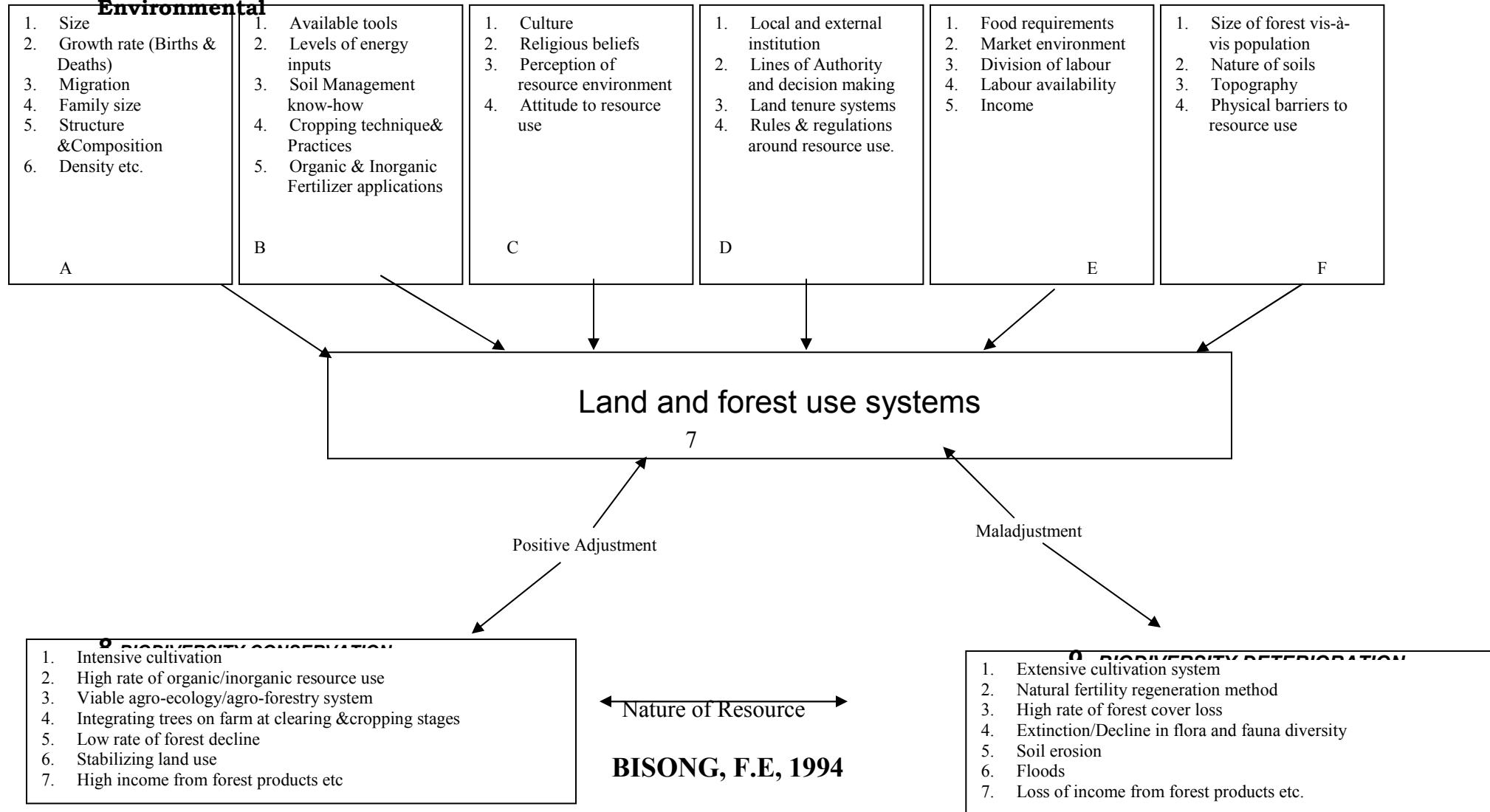
Fig 2 A human ecological system (after Carry & Schwartzberg, 1969)

The utility of the human ecological framework in understanding resource management and degradation process have been criticized for failing to specify in exact terms what is to be included under each of its main dimensions in order to operationalize or state the ways in which they interact. To mitigate this gap, the application of human ecological principles to understanding resource use and degradation processes by small farmers in rainforest regimes was put forward by Bisong (1994). This is diagrammatically presented in Figure 3.

The model shows six major components of Human Ecology i.e., Population, Technology, Social Psychology, Social Organization, Production Organization and State of Environmental Resources. Within these components represented by the boxes (A to F) are indicated specific variables that defines the nature of the land and forest use systems, i.e. factors that drive or influence the use of land and forest resources which correspondingly determines the health and status of environmental resources and human well being.

FIGURE 3: HUMAN ECOLOGY, AGRO-PRACTICES AND BIODIVERSITY CONSERVATION MODEL

1. POPULATION 2. Technology 3. Social Psychology 4. Social Organization 5 Production Organization 6.State of Environmental



Materials and Methods

Location and Area

Settlements in the 'Support zone' of the Oban division of the Cross River National Park, and those around the Cross River North and South Forest Reserves and the Ukon, Umon, Oban East and West Reserves, including numerous tracts of Community Protected Forest areas provide the regional setting for the study. They lie between latitudes $5^{\circ} 20''$ and $6^{\circ} 20''$ N and longitudes $8^{\circ} 05''$ to $8^{\circ} 45''$ E. The forest regions as defined, covers a total area of about 4321.7sq km and accounts for 70.7% of the total high forest estates in the Cross River State (WWF, 1989).

Twelve (12) sampled settlements were chosen for the study (FIGURE 4). A total of four each from the forest charges* of Akamkpa, Oban and Ikom. The 1991 census result puts the entire population of the study area at 290, 548 persons. Population density is significantly lower in the Oban and Akamkpa areas at 22.8 persons per sq km as against 61 per sq km in the Ikom and Etung areas. This however falls below the states' density of 101 persons per sq km (Bisong 1994).

Agriculture is the main stay of the population, engaging about 90% of the people. This is followed by hunting and collection of forest products of largely fruits and spices with about 60% of the population involved (Bisong, 1994).

Agricultural land in the region is predominantly used for the cultivation of plantain and banana farms, perennial tree crop farms; homestead trees and gardens, other staples such as cassava, coco yam, maize, yam, melon etc; and livestock (Okafor, 1989; Holland et al. 1989). Bush fallow cultivation is clearly dominant as it engages about 84% of the population (Faculty of Agriculture University of Calabar, 1987). On the average, cropping and fallow lengths are 11/2 and 5 years respectively while farm sizes are averaged at 3.0 hectares per farm family. Relatively simple tools are used for farm operations often revolving around the machete and hoe.

The frequency of forest clearing is evidently very high as more lands are being sought for the cultivation of crops such as plantain, banana and melon that thrives well only on virgin forest soils in the context of available technology.

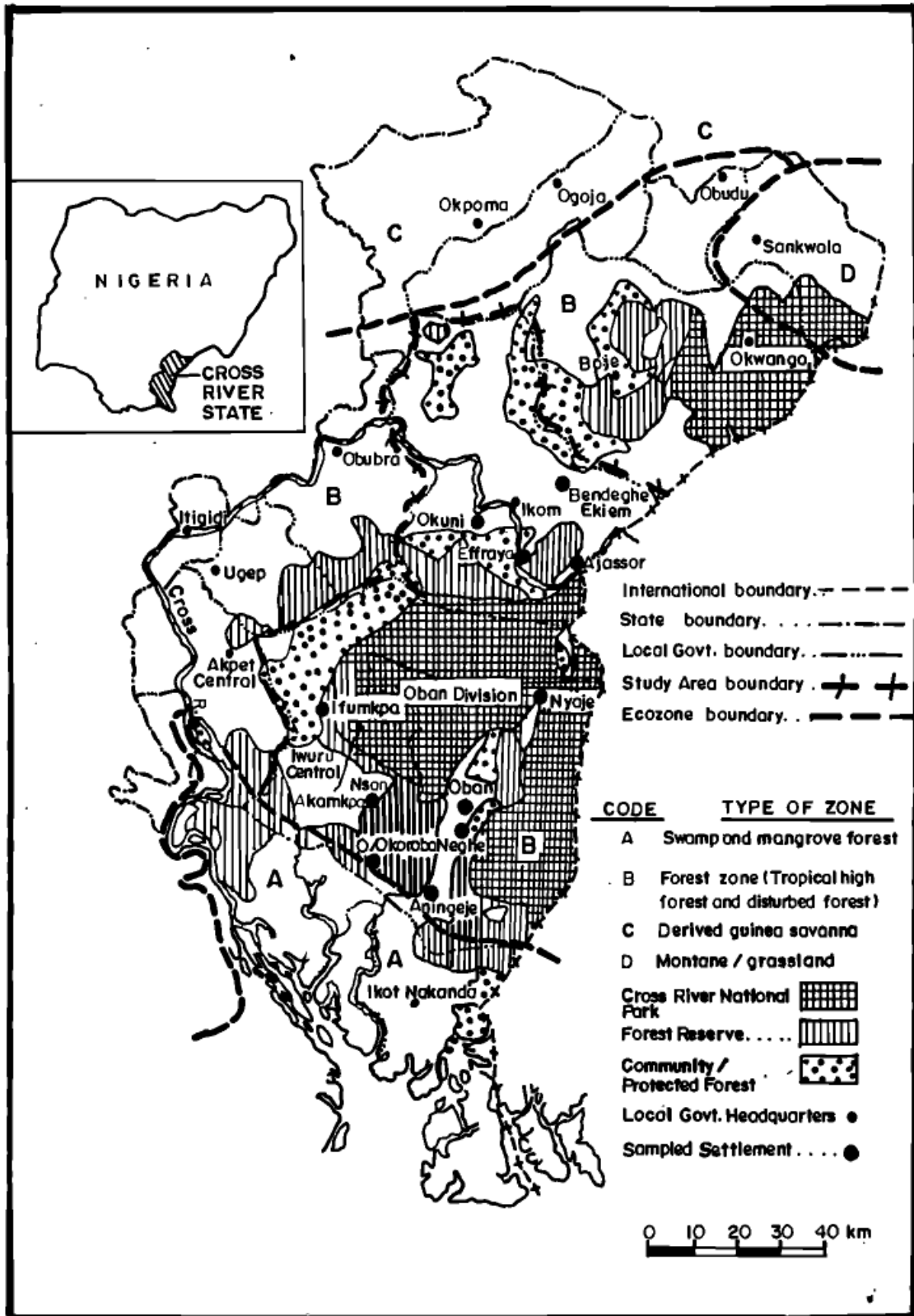


Fig 4: CROSS RIVER STATE SHOWING ECOLOGICAL ZONES, FOREST LAND-USE TYPES AND SAMPLED SETTLEMENTS

The land tenure practice in most of the study area is open access as it permits indigenes the right to claim and own in perpetuity vast tracts of forestland through first clearing. Direct access to forest lands without permission from family head or village head is an established method of acquiring forestlands in the study area. This unregulated access to high forest is however only limited to indigenes of the community. Migrants must gain access to forestlands or farmlands through permission from the village head or the land owning family or wards. The open tenure system along communities in the Cross River High Forest is a critical factor in deforestation. The study is thus cast at investigating the underlying factors motivating deforestation in the context of rural agricultural expansions.

Method of Study

A household questionnaire survey was conducted in the twelve (12) sampled communities within the three main forestry charges. The villages were purposively selected based on proximity to the different forest categories, but stratified to reflect the large, medium and small settlements with respect their population sizes. A total of 864 households were interviewed. Table 1 shows details of the number of sampled households per settlement, the sample coverage, and locational attributes of the settlements.

Information collected through the questionnaire include:

- forest use patterns, size and frequency of forest clearings
- factors influencing farmers decision to clear more lands from virgin forest rather than depending on existing farmlands for cultivation.
- levels of forest use and dependent factors (socio-economic, cultural and ecological) associated with forest cover loss

Table 1: Sampled Settlement And Attributes Of The Study Area

S/n	Settlements	Population size 1993	Estimated Number of Sampled Households	Number of Sampled Households	Percentage of Sampled Households to total number Estimated Households	Locational Characteristics Of Settlements by Forest Category
1	Bendeghe Ekiem (BE)	827	1067	150	14	Community Forest
2	Effraya (EF)	1387	133	50	37	Forest Reserve (Cross River North)
3	Okuni (OK)	5418	584	99	17	Distant Forest Reserve (Cross River South/Community Forest
4	Ajassor (AJ)	5556	410	100	24	Forest Reserve (Cross River North/community Forest
5	Nsan (NS)	2365	211	50	24	Forest Reserve /National Park
6	Oban Okoroba (OO)	378	21	18	86	Enclave in Forest Reserve (Oban west)
7	Iwuru (IW)	1417	151	47	31	Community Forest
8	Ifumkpa (IF)	671	70	50	71	Large Community Forest/National Park/Forest Reserve
9	Oban (OB)	3474	357	78	22	Community Forest/ National Park/ Forest Reserve
10	Neghe (NJ)	590	70	38	54	Community Forest/ National park
11	Nyaje (NJ)	1750	243	63	26	Community Forest/National Park
12	Anningeje (AN)	6710	902	121	11	Forest reserve/ Small community forest
13	Total	37994	4038	864	21	

Factor Analysis

The factor analysis was used primarily as a data reduction technique in the determination of the underlying common factors that are associated with deforestation. The use of factor analytic technique was justified when a key objective and hypothesis was the determination of the critical factors associated with deforestation that were lodged within rural agricultural processes.

Two approaches to factor analyzing the variables and determining the underlying common factors among the variables are adopted in the study. The first is the more direct approach, which entailed the direct reduction of the 33 variables identified from field data to be associated with deforestation to

determine the minimum number of common factors that would satisfactorily produce correlation among the observed variables. The second approach deals with the selection of 12 variables that are highly collinear with the rest of the 21 variables from the correlation matrix of 33 variables. This is based on the principles that the number of variables cannot be greater than the number of cases, that is $n < N$. Since there are 12 villages, not more than 12 variables are thus identified for factor analysis. The 12 identified variables were thus factor analyzed to collapse them to minimum factors that satisfactorily produce correlation among the variables. The rationale for both approaches lie in the need to check for consistency of conclusion to guarantee the stability of the common factors that are finally identified to produce correlation among the variables. The following steps are followed in the factor analysis to achieve the required results. The first is the preparation of appropriate covariance or correlation matrix from the raw data. The second is the extraction of initial factors, which are orthogonal to one another called principal components while the third, is rotation to terminal solution (Kim & Mueller, 1978). The main objective of extracting the initial factors in the exploratory factor analysis is to determine the minimum number of factors that would satisfactorily produce correlation among the observed variables. Usually the first factor extracted explains the largest amount of variation in the data set. The second factor explains the largest amount of variation in the data set of what is left unexplained by the first factor and so on. The explainability of each factor is evaluated using its corresponding eigenvalues.

On the basis of the magnitude of the eigen value, the decision is made on how many factor to retain in the analysis. Two main techniques are available to determine the number of factor to retain. These are the Kaiser's criterion, which requires that those factors whose eigenvalues are greater than or equal to unity are retained (Kim & Muller, 1978; Pacione, 1984; Oyebanji, 1984; Knox, 1990). The other criterion suggest the use of the first number of factors whose cumulative eigen value just amounts to unity. The Kaiser's criterion is adopted in the study to determine the number of factors to retain.

The basic factor analysis model is expressed by the formula:

$$Z_j = a_{j1}F_1 + a_{j2}F_2 + a_{j3}F_3 + \dots + a_{jn}f_n + d_{juj} \dots \dots 4$$

Where:

- Z_j = Standardized factor score of variable j , $j = 1, 2, 3, \dots, n$
- a_{jk} = Standardized multiple regression coefficients of variable j on factor k (factor loading)
- f_k = k^{th} hypothetical common principal factor
- j = Unique factor for variable j
- d_j = Standardized regression coefficients of variable j on the unique factor

The equation shows that a factor score may be decomposed into two parts. The common factor and the underlying structure common to at least one other variable while the unique factor indicates a characteristic unique to that variable.

Frequency Scores

Frequency scores are used to highlight trends in the factors responsible for deforestation and in the data dealing with the importance of market in agro-related decisions. For instance, in examining the critical or leading variables responsible for deforestation frequency statistics was adopted. The frequency scores are derived from table generated from questioning the respondents on the variables of factors influencing their decisions to acquire more land from virgin forest instead of improving the productivity of the lands they already have.

Respondents during the household survey were required to respond to a set of 33 variables built into the questionnaire, which were identified during the PRA studies to influence decisions to clear more forest lands. Respondents were required to respond to each of the variable by stating whether they were correct, partially correct or not correct in influencing their decisions to new clearings from the high forest. Frequency scores were thus generated from the responses by the summation of scores allocated to each response. Variables responded to as correct were scored (2) points, those responded to as partially correct were scored (1) point while those regarded as not correct scored (0). The scores were summed up into a frequency score table, which were further transformed into percentages. The percentage scores were thus graphed to indicate the leading factors among the variables responsible for forest cover loss. Variables that scored between 75 – 100% are classed as very high. 50 – 74% as high, 25 – 49% as moderate and 0 – 24% as low in their respective levels of influencing further deforestation.

Results and Discussion

Factors Motivating Forest Clearing in South-Eastern Nigeria

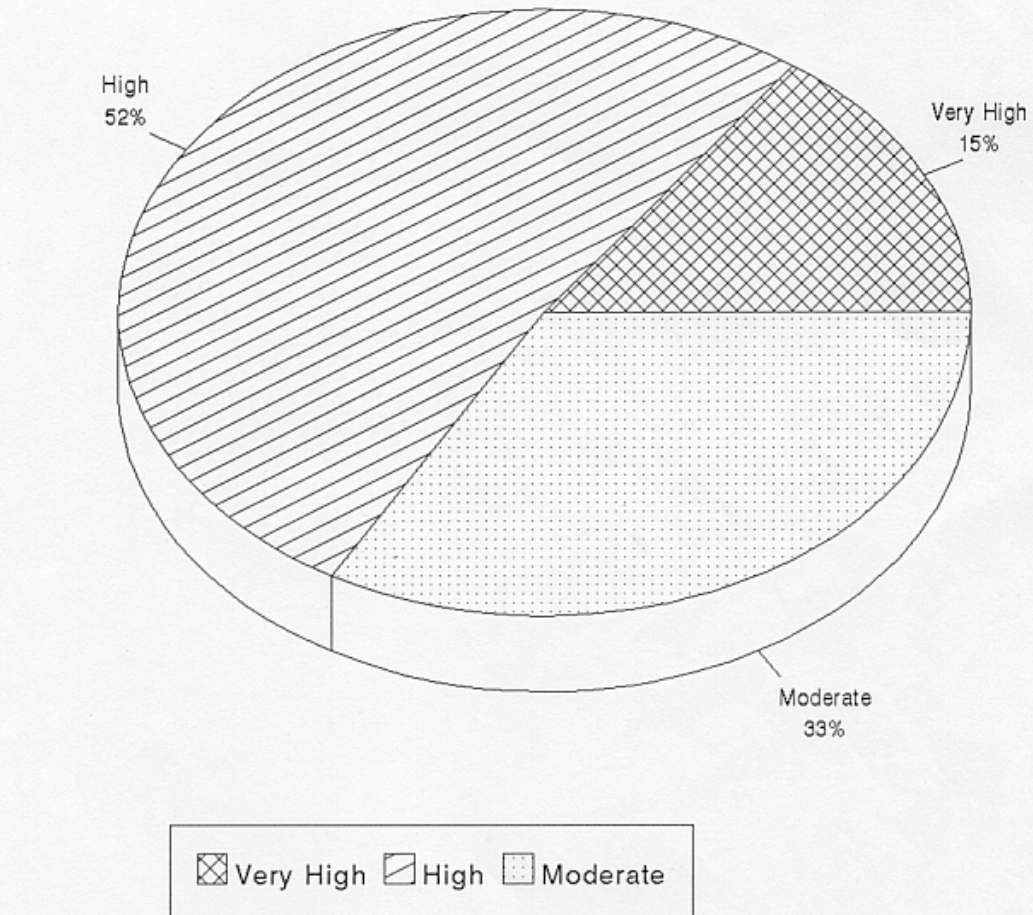
Using frequency scores highlighted in previous section, 33 variables identified to influence peoples' decision to clear virgin forest lands in order to expand cultivation in preference for increasing output through previously acquired lands, were graphed on the basis of their aggregate values.

Aggregate results for the 12 sampled villages (figures 5) indicate that five factors out of the thirty-three emerged as leading in motivating peoples' decision to clear virgin forest lands. These are market demand for agricultural products, income requirements of households, family size and growth considerations, preference for virgin forestlands for cultivation purposes, and the quest for firewood for domestic use.

Fig 5

Levels of Influence in Motivating Forest Clearance

Aggregate for Survey Area



Very High (75-100%)

Market demand
Income
Growing family size
Fertile virgin forest
Firewood for domestic use

High (50-75%)

Tree/cash crops
Food security for coming year
Extra food needs
Inheritance for children
Lessen dependence by children
Declining yield per plot
Customary practice of fallow
Lack of soil management techniques
Fixed cash crops/new land for other crops
Claim establishment
Forest is "no mans" land
Satisfaction from owning personal land
Free access to land as Indigene
Crops require virgin forest
Problems from shared inheritance
Loss farm to settlement growth
Firewood needs

Moderate (25-49%)

Timber/economic trees
Share among spouse
Absence of use restriction
Claim before it is exhausted
Enjoy owning extensive land
To earn large farm title
To avoid distant farms
Low population, much forest
Abundant land
To get firewood for sale
To grow cocoyam/involve women in farm work

The Leading Motivators of Deforestation

Preference for Virgin Forest Lands

Of the five factors enumerated above, preference for virgin forest soils for agricultural purposes is clearly leading. It scored about 1500 in a maximum frequency score scale of 1600 (i.e. about 85%) in the score scale in influencing peoples' decision to deforest virgin lands rather than continually making use of previously acquired or inherited lands. Here lies the principal motivating factor for shifting cultivation or bush fallow agriculture where agricultural expansion is towards the use of virgin forest lands rather than increasing output by additional inputs on existing farmlands.

This quest for virgin forest soils is strongly supported by related factors such as lack of a sustained soil management or improvement technique manifest in the inability to halt yield decline on farmlands. Both factors of a declining yield and lack of a soil management capability were responded to as influencing decisions to clear virgin forest by about 70%. Yield declines in most of the sampled communities usually after a maximum of two to three years of cultivation. The land is thus left to fallow and a new land (virgin forest where it is available) is sought for. This trend usually continues until the last primary vegetation is removed. It will thus appear that halting deforestation and maintaining insitu forest biodiversity is a far dream until a soil fertility management or improvement strategy is put in place.

The above supports the findings by Davies and Richards (1991) in their study of rain forest in Mende life in Sierra Leone that the most important "forest products" as far as local communities are concerned is the fertile soil freed for agricultural purposes through the clearance of forested lands.

Market and Income Considerations

Market demand for agricultural products and the income requirement of households, closely follow the preference for virgin forestland, to the extent they influence peoples' decision to deforest virgin lands. They score 80 and 78% respectively in the influence they exert on decisions to clear new lands and expand cultivation.

Respondents were asked to indicate the varying importance of market in making different agro-related decisions. Of particular import is decision to clear new land for farming. This scored significantly very high at aggregate and charge levels as 80% of respondents indicated the very important role market play in their decision to clear new land for farming.

Family Size and Growth Considerations

Family size and growth considerations of household's ranks among the five leading factors that inform peoples' decisions to seek for new farms from virgin forest. Family size considerations are especially supported by other associated factors (figure 5) such as food security for the coming year, extra food requirements for the household, the need to pass on inheritance to the children and to lessen the dependence of children or make them self sustaining through

allocating them farms plots for their upkeep even while still living with their parents.

All of this play a significant role in contributing to rural people's decision to clear more land from virgin forest and could be appropriately be classed under family size and growth of rural households. Although they could be looked upon as demographic factors, they contain elements of the social psychological attributes such as acquiring virgin forestlands, partly motivated by the need to pass on inheritance to posterity. The above identified factors premised on or supportive of family size and growth consideration of households score high in the levels of influence in motivating forest clearance. They individually account for between 50 – 75% in the extent they influence decisions to deforest virgin lands, thus critical to the deforestation process.

Firewood

The energy requirements of households are the fifth of the five leading factors motivating forest clearance within rural agricultural processes. Rural households do require firewood everyday and most attempt to collect it on a daily basis. There is a strong link between fuel wood availability and deforestation. Women and children who do much of the gathering for rural household consumption are increasingly having to cover longer distance in their search for firewood, as a result of the expanding distance between the village settlement and newly cleared farms around the forest edge where they are readily available.

The Multivariate Nature of Forest Cover Loss

A recourse to figure 5 indicates that the leading factors notwithstanding, critical factors to the deforestation process within rural agricultural context, can be better understood from a complex array of multivariate factors which are very much not mutually exclusive; but rather interconnected and reinforcing one another to exacerbate the deforestation process. The variables that score high as deforestation motivators (50 – 75%), range from the drive to establish and expand tree crop farms or plantations which dovetails into the income and market demand factors, to the factors of extra food requirements of household and food security for the coming year. On the issue of food security in the coming year, a significant proportion of respondent households indicate that there will be shortage of food in the coming year if new farms are not made in the current year's planting season.

The rationale for this they maintain is due to the declining crop yield in older farms lands. Yields are known to decline significantly after a maximum of 2 – 3 years of cultivation in the same plot of land. The security for a harvestable product in the coming year thus lies in making new farms often from virgin forest lands regarded to be more fertile, or in very mature fallow plots of above 7 years old, regarded to have regained fertility. The cycle of a continued and yearly expansion of crop area into virgin forestlands, at the expense of a severe loss of forest biodiversity thus remains the vogue, in the absence of the technique of intensifying cultivation through additional on-farm resource input to maintain soil fertility.

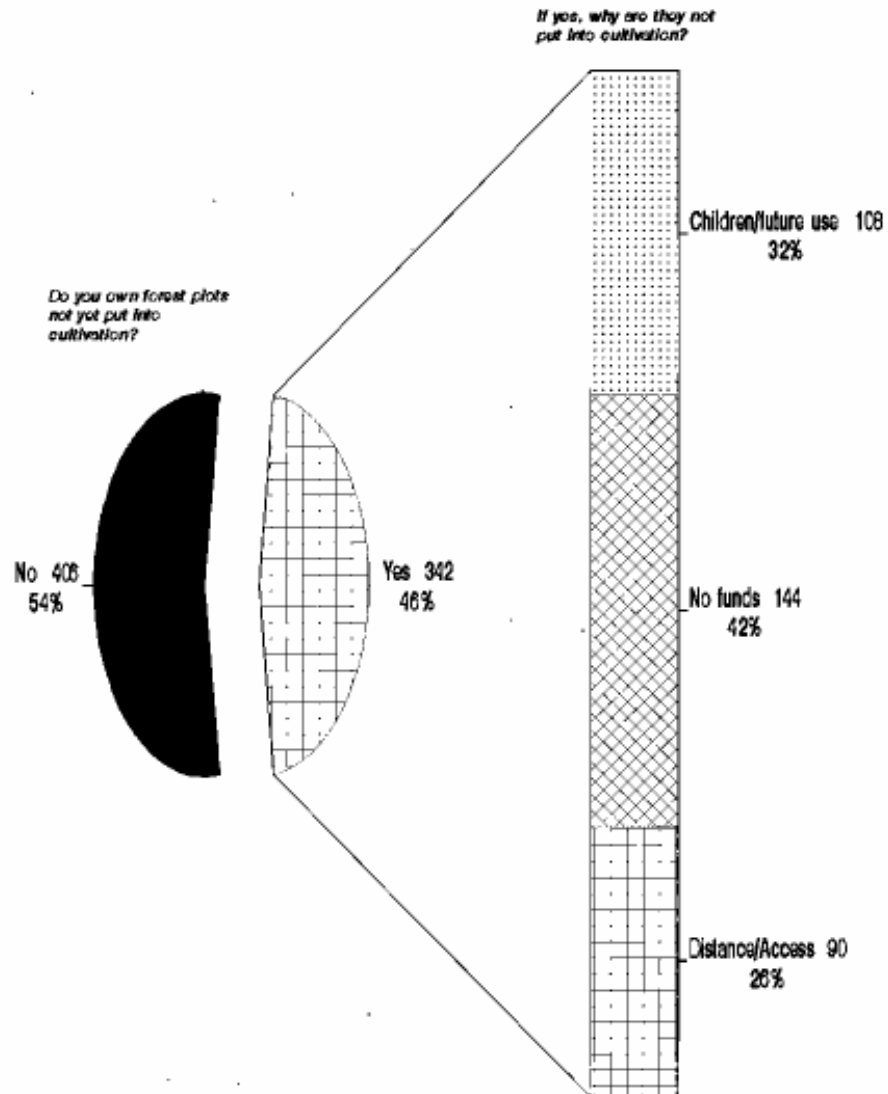
Social Psychological Factors

There are also social psychological factors ingrained in the reaction of farmers to the subjective realities of their environment that are critical to the deforestation process. They include the drive to establish claim and control over tracts of virgin forest lands not for their immediate utility but for future requirements, the mental perception of the forest as no mans' land, the psychic satisfaction from owning lands personally cleared from virgin forest rather than depending on that transmitted through inheritance from parents and the open land tenure system which allows indigenes an unlimited and unregulated access to virgin lands. (Figure 5) The social psychological factors seem to be fuelled by the nature of the land tenure practice that permits an unrestricted and uncontrolled claim to communal lands. Forestlands in the study area belong to those who first clear them often without prior consultation with or approval from the family, village or clan head. Thus the forest is usually perceived as no man's land permitting the drive to establish claim to the extent of ones financial capability over any tract of uncolonized of virgin land.

This system may have been adequate in the past when population densities were low and the local economy free from the competitiveness of the modern economic sector. Today the opening of the once rural economy to the market sectors have permitted local elites to take advantage of the porous land tenure situations to deforest massive virgin lands just to establish claim over presently not required lands. As much as 54% of the sampled population own forest plots through clearing them to establish claim but have no immediate cultivation plan (Figure 6). This implies that deforestation proceeds not only purely from the utilitarian point of view premised on translating forest to farm lands for the purpose of sustaining livelihood but for the numerous other subjective influences.

This situation is very salient and perhaps the most critical under lying factors behind the present wanton destruction of forest lands through presently not required clearing premised on the need to establish claim and control for the future. The social psychological factors have unfortunately not yet been reflected in the numerous literature on deforestation; perhaps much due to an improper appreciation of the nature of the deforestation problem.

FIGURE: 6 Forest Plots Owned and Cleared but not yet put into Cultivation
Aggregate for Survey Area



Farming Systems, Human Ecology and Resource Conservation in the Cross River Rain Forest.
Bisong F.E (1994)

Factor Analysis of Deforestation Variables

Analysis of the 33 variables identified in the previous sections to influence people's decision to encroach into forest lands rather than improve productivity on existing lands meets with some operational difficulty due to the share size of variables involved as well as the overlapping nature of the variables which makes description difficult. The factor analytic technique is here employed to reduce or collapse data for parsimony of description.

The above technique assumes that several measurements may show basically the same pattern of variation, which accounts for the redundancy of the identified factors in explaining the phenomena, in question. The factor analysis technique thus serves to identify major factors, approximates them together for the purpose of being regrouped. The few dominant factors to emerge are thus expected to provide the same information

The thirty-three variables identified to have relevance in influencing people's decision to clear more forest were therefore subjected to a factor analysis. The variables are shown in table 2. A correlation matrix was first computed using raw data matrix of deforestation factor in the 12 sampled settlements.

The results show positive correlation for most of the variables with a number of them having high correlation coefficients with several others. The 33 variables were collapsed into five factors on the basis of variables having latent roots or eigenvalues greater or equal to unity (1.0) in accordance with Kaiser's selection criterion. The extracted factors are orthogonal or independent from the other. These are shown in Table 3.1 below.

Table 2 Variables for Factor Analysis

1	VAR1	Market Demand.
2	VAR 2	Income.
3	VAR 3	Timber/Economic Trees.
4	VAR 4	Trees/Cash Crops.
5	VAR 5	Future Food Security.
6	VAR 6	Extra Food Needs For Households.
7	VAR 7	Growing Family Size.
8	VAR 8	Children Inheritance.
9	VAR 9	Lessen Child Dependence.
10	VAR 10	Land to Share Among Wives.
11	VAR 11	Fertile Virgin Forest.
12	VAR 12	Decline Yield Of Farmland.
13	VAR 13	Customary Practice Of Fallow.
14	VAR 14	Lack Of Soil Management For Continuous Yield.
15	VAR 15	Permanent Nature of Cash Crops Necessitating new Farms For Food Crops.
16	VAR 16	Claim Establishment.
17	VAR 17	Forest Is No Man's Land.
18	VAR 18	No Use Restriction.
19	VAR 19	Satisfaction From Land Personally Acquired.
20	VAR 20	Free Access as Indigene.
21	VAR 21	Rush to Claim Exhaustion Due to Migrant Influx.
22	VAR 22	Enjoy Owning Extensive Lands.
23	VAR 23	To earn Land Title and Respect.
24	VAR 24	Grow Crops, Which do well on Virgin Forest Lands.
25	VAR 25	Own Personal land to avoid problems from shared inheritance.
26	VAR 26	Drive to claim nearby lands to avoid distant farmlands.
27	VAR 27	Small population and vast territory.
28	VAR 28	Land is available and abundant.
29	VAR 29	To expand village territory.
30	VAR 30	New land from virgin forest as settlement expansion takes over old farmlands.
31	VAR 31	Firewood for sale.
32	VAR 32	Firewood for domestic use.
33	VAR 33	To involve women in farm work who mainly grow coco yam, which requires virgin forest soils.

Source: Bisong, 1994

Table 3 Eigenvalues and Factors from 33 Variables

Factors	Eigenvalues	% Of Total Variance Explained	Cumulative % Of Variance
1	15.421	46.7	46.7
2	5.416	16.4	63.1
3	4.377	13.3	76.4
4	2.645	8.0	84.4
5	1.299	3.9	88.4

Source: Bisong, 1994

The five factors together account for 88% of variation among the variables. From the loading of the factors on the variables, the variables, which load high on the five major factors are collated and labelled in Table 4.

Table 4 Characteristics of the Major Factors

Factors	Variable Loadings	% Of Variance	% Of Cumulative Variance	Factor Label
1	(19,25,8)	46.7	46.7	Social Psychology
2	(31,15,14)	16.4	63.1	Income/Food crop Requirements
3	(11,12)	13.3	76.4	Preference for Virgin Forest Soil/ Yield Decline
4	(3,4)	08.0	84.4	Timber Potential/ Plantation cash crop Development
5	(13)	03.9	88.4	Customary Practice of Fallow

Source: Bisong, 1994

Although five factors are suggested, the first three factors could be considered critical to explaining the phenomenon of deforestation as they account for (76.4% of total variance to deforestation among the 33 variables.

The results obtained from the above direct application of factor analysis, although consistent with certain trends in field observation needed to be cross checked to ensure validity of conclusion by the application of a modified approach to factor analysis. In this approach, 12 factors that were highly collinear with the rest of the 21 variables from the correlation matrix of 33 variables were identified and selected for factor analysis. Twelve were selected because the number of variables cannot be greater than the number of cases, that is, $n > N$. Since there are 12 sampled villages (cases) the selected number of variables for the principal component should be less than or equal to the number of cases. The results of the factor analysis are presented in Table 5.

Results from table above indicates that the 12 collinear variables selected from the 33 variables can be conveniently collapsed in two dominant factors using Kaiser's criterion. The two factors 1 and 2 accounts for 83 percent of the total variation among the variables. From the loading of the factors on the variable, the factors, which load high, are labelled and shown in Table 6. —

Table 5 Eigenvalue and Cumulative Percentage (Modified Approach to Factor Analysis)

Factors	Eigenvalues	% Of Total Variance Explained	Cumulative % Of Variance
1	7.989	66.6	66.6
2	1.969	16.4	83.0
3	0.773	6.4	89.4
4	0.546	4.5	94.0
5	0.284	2.4	96.3
6	0.205	1.7	98.0
7	0.099	0.8	98.9
8	0.079	0.7	99.5
9	0.038	0.3	99.8
10	0.015	0.1	100.0

Source: Bisong, 1994

Table 6: Characteristics of Major Factors (Modified Approach)

Factors	Variable Loadings	% of Variance	% of Cumulative Variance	Factor Label
1	(19, 8, 17)	66.6	66.6	Social Psychology
2	(11)	16.4	83.0	Preference for Virgin Forest Soils

Source: Bisong, 1994

Tables 4 and 6 summarise the results of both approaches to the factor analysis, which were primarily intended to reduce or collapse the 33 variables identified to influence decisions to clear more forests lands. From both approaches, the number one factor accounting for the greater variation in influencing the decisions to deforestation are the social psychological factors. This account for 46.7 percent in the first approach and 66.6 percent in the second (modified) approach. Social psychological factors have been discussed in the previous section as with other variables identified to be significant. They range from the drive to establish claim and control over forest land to pass on to progeny, to the satisfaction derived from owning lands personally acquired through self effort rather than having to own only that which was passed on through inheritance from parents no matter how sizeable.

These and other associated factors as shown in the graphs and confirmed to be significant by the factor analysis are premised on the land tenure systems prevalent in most of the high forest regions of Cross River State which allows unfettered access to forest resources and permits such to be held in perpetuity unto descendants.

The second factor on the first adopted approach to factor analysis (Table 5) is labelled income and food crop requirements. The variables that load high on this factor are the search for fire wood for sale (VAR 31) the search for new farm

plots to grow food crops due to the permanent occupation of lands under cash crop cultivation in the cultivation of cash crop such as cocoa, palm and rubber (VAR 15), and the lack of capability to make soils sustain good yield on a permanent basis which necessitates the search for new lands (VAR 14). These and the associated variables in this group are labelled as income/ food requirements factor. They account for 16.4% of the explanatory variance in deforestation. This is followed by the factor labelled preference for virgin forest soil/ yield decline on existing farmlands. This factor accounts for 13.3% of total explanatory variance in deforestation.

The analysis involving the second approach to factor analysis had clearly shown social psychological factors to be the lead factor explaining 66.6% variance among the 33 variables influencing deforestation (Table 6). This has been earlier discussed and here alluded to in confirmation of its validity.

The second significant factor in the modified approach adopted is the preference for virgin forest soils. Variable 11 loads highly on this factor and accounts for 16.4% of total variance among the variables influencing deforestation. Together with social psychology factor, they cumulatively account for 83% of total variance influencing decision to deforestation. Although the modified (second) approach confirms considerably trends in the first adopted approach, it can be said to attain more parsimony of description in that it collapses the 33 variables to two dominant groups – the socio-psychological factors and the preference for virgin forest soils which together sums up to 83% of variation among the 33 identified variables.

The above very much confirms field observations where the land tenure system, a principal variable in human social organization around resource use, and the perception of virgin soils, a principal land use variable are found to be highly significant in affecting much of deforestation in the Cross River rain forest.

Conclusion

The conclusion to be drawn from the above analysis is that although 33 variables have been identified to influence the farmer in his decision to deforest more lands, these variables are intricately interrelated and have a significant degree of collinearity amongst them and hence can be collapsed into a few principal variables for ease of description. They are social psychological factors, preference for virgin forest soils for their perceived fertility; income requirements; the customary practice of fallow and the development of plantation agriculture. The factor analysis results confirm to a significant degree the frequency score analysis reflected in the graphics earlier presented that show preference for virgin forest soils; market demand for products and household income requirements; family size and growth considerations; energy related needs and socio-psychological factors as critical deforestation motivators. The foregoing validates the research hypothesis. Strategies to combat deforestation by small farmers must incorporate or rather be contextulized to deal with factors that motivate the farmers division to colonize new lands.

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The BECE Grading System Committee Report: Implications for Minimum Educational Qualifications for Basic Education Certificate

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Abstract

In spite of the low attainment obtained by pupils at the end of primary education in Criterion Referenced Tests (CRT), the performances of these pupils at the end of junior secondary education, as evidenced by results of the Basic Education Certificate Examinations (BECE), were surprisingly normal. Some heads of senior secondary schools (SSS) and concerned educators in the country have observed that there is no match between the apparently high achievement of pupils in the BECE and their performance at the SSS level, and for that reason criticized the validity of the BECE. These criticisms led to the setting up of a committee by the Director General of the Ghana Education Service (GES) to examine the BECE and its grading system and make recommendation for its improvement. The committee found the norm-referenced grading system with the percentage passes already fixed (also referred to as the ‘*Stanine*’ system) which was used in the BECE as the major cause of the inefficiencies. It recommended in its place the use of a flexible 9-scale criterion referenced grading system that will reflect variations in the performances of pupils from year to year. The success of the new grading system will depend largely on clearly defined list of grade descriptions for critical grades identified (i.e. Grades 2, 6 and 8). This presentation examines the need to specify the grade descriptions that should match the lowest critical grade (i.e. grade 8), which may be considered as the minimum educational qualifications for basic education.

Introduction

In view of the nation's educational reform programme launched in 1987, the first nine years of schooling, which is free and universal for all children aged normally between 6 and 15 years, is described as *basic education*. According to the document, ‘*Report of the Education Commission on Basic Education*’, “basic education is the minimum formal education to which every Ghanaian child is entitled as of right, to equip him/her to function effectively in the society” (GMOE, 1986:3).

Basic education connotes the attainment of certain minimum levels of educational goals – the mastery of some basic knowledge and skills (Akplu, 1999). The emphasis on junior secondary education in the early part of the reform was therefore to ensure every child is equipped with the essential knowledge and skills that can make him/her develop the ability to function effectively in the society. In other words, the need to make the first half of secondary education *comprehensive* (i.e. accessible to as many children of school-going age as possible) is to ensure the youth is equipped with the essential knowledge and skills that will make them interact meaningfully with their changing environment and adapt to the advancement in science and technology in the society.

In Ghana, what pupils must experience in basic school in order to acquire these essential knowledge and skills, which are the *minimum levels of educational goals each individual is expected of*, as a right, are contained in the subjects taught at the junior secondary level. These subjects are Ghanaian Language and Culture, English, Mathematics, Integrated Science, Agricultural Science, Pre-Technical Skills (including Technical Drawing) Environmental Studies, French (optional for schools), Life Skills, Religious/Moral Education, Music & Dance, and Physical Education.

This suggests the minimum pass levels required in all the subjects should define the criteria for basic education. Minimum educational requirements become synonymous with basic education. Basic education concept therefore embodies a philosophy that has implications for assessment, grading and certification of junior secondary school graduates.

Concerns about Poor Achievement at the Basic Level

Five years after the Educational Reform Programme initiated in 1987, national tests, designated Criterion Referenced Tests (CRT), were conducted for pupils in the final year in primary education in regions throughout the country. The CRT results from 1992 to 1997 indicated that, on the average, less than 7 per cent of pupils reached a mastery level of 60 per cent in English Language, and less than 3 per cent of them reached mastery level of 55 per cent in mathematics.

In spite of the low attainment observed at the end of primary education, the performance of these pupils at the end of junior secondary education, as evidenced in results of the Basic Education Certificate Examinations (BECE), was surprisingly normal. Some heads of senior secondary schools (SSS) and concerned educators in the country have observed that there is no match between the apparently high achievement of pupils in the BECE and their performance at the SSS level, and for that reason criticized the validity of the BECE. These criticisms led to the setting up of a committee in September 1999 by the Director General of the Ghana Education Service (GES) to examine the BECE and its grading system and make recommendation for its improvement. Prof. D. A. Akyeampong, the chairman of the committee, submitted the committee's findings and recommendations to the Director General in April 2000.

The Old BECE Grading System

Akyeampong et. al. (2000) observed that the procedure used currently in processing BECE results, that is, the BECE grading scheme, is called the Stanine system, which is a 9-scale standardized grading system. The Stanine is a norm-referenced grading system; thus one that allows students to be compared in order to establish a hierarchy of excellence that is used in grading, certification and selection.

Under the Stanine system, grading is related to fixed norms. In other words, proportions of the candidates entered for the examination define the grades and these remain unchanged from year to year, as shown in Table 1.

Table 1 Percentage Number of Candidates obtaining each Stanine Grade

Year	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8	Grade 9
1995	4	7	12	17	20	17	12	7	4
1996	4	7	12	17	20	17	12	7	4
1997	4	7	12	17	20	17	12	7	4
1998	4	7	12	17	20	17	12	7	4
1999	4	7	12	17	20	17	12	7	4

Source: Akyeampong, *et al.*, (2000:5)

The Stanine scale is a form of raw score transformation into a scale. The transformed values are assigned the numbers 1, 2, 3, ... 9, hence the name Stanine, which is the acronym of *standard nine*. The system provides a type of norm that shows a candidate's position within his/her own cohort in a particular subject for a particular year. From Table1, it is clear that 77% of the candidates obtained the Grades 1 - 6 in every subject implying that irrespective of what highest mark or lowest mark in a subject is, this same percentage pass would be obtained yearly.

Besides the ease with which Stanine grades can be computed, the system was found to be the best system that could be used for both certification and selection after the abolition of the common entrance examination in the early years of the Educational Reform.

However, since it is the norm-referenced grading system with the percentage passes already fixed, it was found to have several demerits. Major among these demerits, according to (Akyeampong, et al., (2000) are:

- i. It makes it almost impossible to compare candidates' performance and to determine from year to year whether or not there has been a nationwide improvement. For instance, the minimum raw score for the top 4 per cent obtaining Grade 1 in mathematics one year can be 78%, and in another year this can get as low as 56%, and yet 4 per cent of the candidates will still obtain a Grade 1.
- ii. It does not reflect steadily rising or declining standards at the basic level, and thus, the results neither reflect improvements in teaching and learning nor in candidates' performances.

The BECE grading system committee therefore recommended in its place the use of a flexible 9-scale criterion referenced grading system that will reflect variations in the performances of pupils from year to year. The new grading system, which was to take effect from the August 2000 BECE, is yet to be used.

The New BECE Grading System

Basic Education focuses on broad curriculum goals and the Basic Education Certificate Examination (BECE), an essentially school leaving examination, should assess candidates' achievements across a wide range of content and objectives and so measure what the students have learned within that context (Akyeampong, et. al., 2000). Selection for further education is simply one of the objectives of the BECE. Though the Stanine grading system makes the BECE useful mainly for selection to further education, it provides little information about what the majority of pupils who fail to qualify to the

SSS know and can really do, and hence make their placement into other areas of further education and apprenticeship difficult.

The *flexible 9-scale criterion referenced grading system* recommended in place of the Stanine grading system is based on three key elements:

- Grade Descriptions; i.e. competencies which a candidate obtaining any of the key or critical grades (i.e. grades 2, 6 and 8) should be able to demonstrate;
- Grade Setting; i.e. using Grade Descriptions after marking the examination scripts to advise on scores which will match the critical grades.
- Grade Cut-Off Points; i.e. using the set critical grade scores to determine the cut-off scores for all other grades.

The success of the new grading system depends largely on a clearly defined list of grade descriptions for the key grades.

The *flexible 9-scale criterion referenced grading system* recommended in place of the Stanine grading system can be seen in Table 2.

Table 2 Grade Interpretations in the New Grading System

Grade	Interpretation	Grade	Interpretation
1.	Excellent	6.	Low Average
2.	Very Good	7.	Low
3.	Good	8.	Lower
4.	High Average	9.	Lowest
5.	Average		

Source: Akyeampong, et al., (2000:17)

One thing that is obvious from Table 2 is the absence of the grade labeled '*fail*'. The interpretation for Grade 9 is now '*lowest*'. This is in agreement with current thinking that every child achieves, at least, some basic knowledge and skills by the end of basic education. Labeling a child as a *failure* is no more acceptable, because it raises questions about who has failed. Is it the child who has failed to attain the basic education, which is his/her right? Or is it the educational system that has failed to provide adequate opportunities for the child to attain this basic right?

Results of the Trial Testing the New Criterion Referenced Grading System

In order to make a satisfactory transition from the old to newly proposed system, the committee recommended a trial of the procedure to be carried out using the 1999 BECE results. In September 2000, the West African Examinations Council (WAEC) constituted Subject Awards Panels to carry out the trial. The panels were made up of Chief examiners and Team leaders of the various subjects as well as subject experts from the Curriculum Research and Development Division (CRDD) of the GES and resource persons from the universities.

At the trial award meeting, grade descriptions were formulated, discussed and documented for the critical grades (i.e. grades 2, 6 and 8). A list of the grade descriptions

for three subjects – English, Mathematics and General Science – can be seen in Appendix A. The various subject panels fixed scores for the critical grades using the grade descriptions. The critical grade scores were then used to determine the cut-off scores for all other grades.

Unlike what pertained in the Stanine system, results of the trial test showed marked differences in percentage passes from subject to subject. Using the new criterion referenced grading system, percentage passes at Grades 1 and 9, which were 4% in either case in the Stanine system, were different as shown in Table 3.

Table 3 Percentage passes at Grades 1 and 9 in the New Grading System

		English	Mathematics	General Science
Grade 1	New	0.8	1.2	0.5
	Stanine	4	4	4
Grade 2	New	2.3	1.3	1.6
	Stanine	11	11	11
Grade 3	New	12.1	5.1	6.9
	Stanine	12	12	12
Grade 8	New	17.4	9.5	9.5
	Stanine	17	17	17
Grade 8	New	21.8	32.8	34.2
	Stanine	7	7	7
Grade 9	New	19	26	23
	Stanine	4	4	4

(Source, WAEC, 2000:3)

Also with new grading system, cumulative percentage passes at Grades 2, 6 and 8, which were fixed as 11%, 77% and 96% respectively in the Stanine system, were completely different as shown in Table 4.

Table 4 Cumulative percentage passes at Grades 2, 6 and 8 in the New Grading System

Subject	Cumulative Percentage Passes		
	Grade 2	Grade 6	Grade 8
English	3.1	44.1	81.0
Mathematic	2.5	23.3	73.4
General Science	2.1	24.7	76.7

(Source, WAEC, 2000:3)

Table 4 shows that in terms of real attainment in the subjects presented, the majority of the pupils are achieving just the minimum from what the educational system can provide. In mathematics, 53,735 candidates out of the 230,215 that entered the examination (i.e. less than 25%) of the candidates obtained Grades 1-6. The situation is not very different for General Science.

Validity of the BECE

The analysis of the 1999 results with the new grading system indicated that in all the subjects the majority of pupils are in the low, lower and lowest grades. This development has several implications for the validity of the BECE. Commenting on this in a recent publication of the Daily Graphic in an article captioned '*The Examinations that Failed*', Asante (1996), pointed out that

When many students fail an examination, we may blame the students, the teachers or both. We seldom question the examination which failed the students. We take the validity of the examination for granted. But our JSS and SSS examination results suggest that the examinations have on the whole failed us. The examinations have largely failed us because their aims are blurred and their objectives multi-purpose.

Our curriculum goals for basic education are not clearly defined. This problem must be confronted. Access, quality and management efficiency, which have been emphasized for some time now, are overall system goals, and there is the need to take a critical look at what should really constitute 'basic education' for now and the future. In other words, there is the need to define what should *constitute*

- the *minimum (or basic) educational qualifications* required at the end of junior secondary school; and
- the *further educational qualifications* that are necessary at the end of junior secondary school for entering senior secondary schools.

Even though grading for the basic education certificate uses both BECE performance and continuous assessment summary, it is not based on any of the above criteria. The BECE uses an assessment scheme that requires students to possess a certain set of knowledge and skills before they can pass. Those who cannot demonstrate their possession of these are failed. The level required to pass is however high, and among those who fail are in fact many who possess a substantial set of attainments which go unrecorded because the *minimum educational qualifications* required at the end of basic education is not clearly defined. That is, the grade descriptions that should match the lowest critical grade (i.e. Grade 8), which may be considered as the minimum educational qualifications for basic education, need to be clearly documented before the BECE can be made to do what it is really intended.

Recommendations for Improving the Validity of the BECE

The type of assessment scheme required by the comprehensive secondary education system we have in this country today is one which will ensure all students do reasonably well or do not feel failures. It is one that can encourage *positive achievement*. Positive achievement refers to the actual attainments of the student in a subject. The assessment scheme should enable students to demonstrate what they know, understand and can do rather than what they do not know. To do this, the scheme must ensure that the examinations given match the

level of the students' attainments. This can only be done where the *minimum educational qualifications* required by all is clearly defined and differentiated from those that are necessary for entering senior secondary institutions.

For each subject offered at the JSS level, there must be a list of topics covering the knowledge and skills that can be appropriately learned by all students at this level. The *appropriateness* of this list should be related not only to the students' ability to cope with the content but also to what will be useful in the future for the majority of students whose formal education is likely terminate at this level. Such a list may be called the *core curriculum* of the subject at a particular level.

Sometimes the term core curriculum is used when referring to all the subjects at a particular level. The core curriculum in this case is the compulsory subjects that all the students studying at a particular level are required to take. The secondary curriculum can be likened onto a mango fruit. The central part of this fruit is the **core**, which contains the seed. On the core is the **flesh**, which contains the sweet yellow juice that we suck.

Similarly, the curriculum can be said to comprise *a core content* and *additional content*. The core curriculum content is analogous to the basic list of topics covering the knowledge and skills that can be appropriately learned by all. At the junior secondary school (JSS) level, the basic list must contain *a list of items that indicate the minimum level of performance expected* of any student completing school at this level. This is what curriculum experts actually refer to as the *core content* (or core curriculum) in a subject.

For the purpose of assessment, the core curriculum at the junior secondary level should comprise knowledge and skills considered appropriate for students in about the lowest 40 per cent of the range of attainment. At the JSS level, these are students who normally would not have attempted any form of secondary education had it not been the reforms in education. They are students who would have found it impossible to get into secondary education since they could not have passed the competitive common entrance examination, which was stopped as a result of the reform. The students in the lowest 40 per cent of the ability range in JSS should therefore not be bothered too much with what those who would eventually pass to senior secondary should be able to do.

There is the need for both natural and social scientists of the nation to begin to think of what should constitute basic knowledge in all basic subjects. The GES should make its position clear on what every child really needs, and is capable of doing, in science in order to contribute his/her quota to the development of this country. Such minimum knowledge and skills that are essential not only to ensure the individual's survival in society, but also his/her ability to contribute to the development of the society, is the culmination of what may be described as '*basic education*'.

The practice (or traditional model of curriculum development) where a few educators are handpicked and camped for a couple of weeks to prescribe what should go into the basic school curriculum is of little value. The result is that the official basic school curriculum is of little relevance to the needs of the majority of pupils terminating their formal education at this level. Table 5 is the grade descriptions used by the Mathematics award panel in testing the new grading system.

Table 5 Trail BECE Standard Fixing and Subject Grade Awards: Mathematics Grade Descriptions

GRADE	DESCRIPTION
8	The candidate should have an idea of numbers and be able to carry out the basic four operations on them. The candidate should apply the idea of numbers to measurement and identify shapes.
6	In grade 6, the candidate should be able to translate simple word problems involving single idea into mathematical sentences and solve them using a combination of the basic operations. The candidate should be able to demonstrate the need for accuracy in measurements, translate mathematical ideas/concepts pictorially and identify shapes and their properties.
2	The candidate in this grade should demonstrate different strategies in the solution of mathematical problems, demonstrate a high degree of accuracy in solving problems and display mathematical concepts, skills and strategies and come out with logical conclusions.

The competencies described under Grades 8 (i.e. what the majority of pupils who are likely to terminate their formal education should score) are too sketchy. Many educators here are in the field, interact and/or see how most of our youth who had no tertiary education live and carry out their economic/everyday life activities. We are therefore the right body to support the Curriculum Research and Development Division of the GES and WAEC to list all the necessary knowledge and skills that are required to make the Ghanaian child numerate and literate in the twenty-first century.

Conclusion

An assessment scheme that is intended to test for minimum competency cannot at the same time do a good job in selecting students for higher academic pursuits. An assessment scheme for testing for minimum competency should utilize both a criterion-referenced testing and grading system. Therefore your input on what should constitute minimum scientific knowledge and skills that are essential for the development of *basic education* will be very appreciated to make our educational system more functional. There is need to constitute new subject panels to tackle the question of the minimum qualifications in each subject; and also there is the need to adopt an assessment system that will ensure that every child attains his/her '*basic education*'. [The writer was in the 6-member BECE Grading System Committee]

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Appendices

APPENDIX A

TRIAL BECE STANDARD FIXING AND SUBJECT GRADE AWARDS

GRADE DESCRIPTIONS: ENGLISH LANGUAGE

GRADE	DESCRIPTION
8	A candidate within this grade should be able to understand and carry out simple instructions in the language.
6	To get this grade the candidate should be able to understand and use the language in its simplest form. He/she or she should be able to express himself or herself using the basic structures.
2	This candidate should have a good control of the English Language. He/she should be able to understand, interpret and communicate effectively using appropriate registers, idiomatic expressions and varied sentence structures.

**TRIAL BECE STANDARD FIXING AND SUBJECT GRADE AWARDS GRADE
DESCRIPTIONS: GENERAL SCIENCE**

GRADE	DESCRIPTION
8	<ul style="list-style-type: none"> a. Definitions b. Measurements and units c. Knowledge of common diseases in Ghana and their prevention.
6	<ul style="list-style-type: none"> a. State differences and similarities. b. Draw and label diagrams c. State basic functions d. Explanation of basic terms e. Description of processes f. Simple classifications (e.g. living things and non-living things; acids and bases)
2	<ul style="list-style-type: none"> a. Classification (e.g. levers, metals and non-metals, reactive and non-reactive metals) b. Demonstration of concepts c. Perform calculations accurately d. Explanation of principles and underlying concepts e. Write and balance chemical equations.

The Role of Information Communications Technology (ICT) in National Development: The Challenges for Our Society

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Abstract

This paper seeks to contribute to the national ICT awareness education to bring to the fore the benefits of ICT. We look at the impact and challenges posed by the information revolution. We also discuss the national ICT policy framework and suggest the need for integrating the rather fragmented ICT infrastructure in Ghana.

Keywords: Development, ICT infrastructure, Education, human resource, challenges of ICT, ICT policy

Introduction

Education is the key to the development of every nation, developed and developing ones alike. According to Thompson (1981, age 21):

Development is a process of enabling people to accomplish things that they could not do before. That is attained when people learn to apply information, attitudes, values and skills previously not available to them. Learning is not usually enough by itself. Most aspect of development requires capital investment and technical process. But capital and technology are not without human knowledge and effort. In this sense, human learning is centred on development.

Thus education and development are bedfellows; a sort of symbiotic relationship exists between the two. The driving force behind both education and development, however, is the judicious application of new technologies, technologies that would ensure quality and functional education, efficiency at workplaces and increased productivity in businesses.

National ICT Policy

When the citizens vibrate in resonance with the leader's vision, the implementation of national policies finds willing, enthusiastic support of the broad mass of the people. We once were at such a crisis when a couple of years ago we as a nation embarked upon

national educational reforms; FCUBE, Functional Literacy Program and others. Today we have found ourselves reforming the reforms in so short a period of the implementation of these reforms. Every Ghanaian knows why there is the need for reforming the reforms, but to make it blunt, we would say that the reforms never succeeded in reforming anything. The recent mess at the BECE reminds us about the magnitude of our problems at the education sector. The contents of the reforms package were laudable and no sane person can say a word against them. But the implementation was fraught with problems, problems that ensured the stillbirth of such an important national policy. The teachers, the universities and other stakeholders were either not involved directly or the policy makers ignored their views. Some Ghanaians argued that government was wasting our limited resources on the FLP in particular. One of these views appeared in an article by Apostle Kwamena Ahinful titled "Row over new varsity fees" in the "MIRROR" In this article he said.

Why do we saddle ourselves with misplaced priorities using precious funds to educate the uneducated old folks who are only nearing their graves? Of course university education is more important than non-formal education. Let us therefore forget about this non-formal education idea for the moment until satisfactory financial attention has been given to university education first then later with any surplus money we can look at the non-formal education"

Others saw the introduction of the NFED as a perfect strategy to amass votes from the rural folks. According to the NFED, however, there was a good justification for the introduction of this sector. A citation from the facilitators' manual will bring the point home in this case.

A person is literate, when he has acquired knowledge and skills which enable him to engage in all those activities in which literacy is required for effective functioning in his group and community and whose attainments in reading, writing and arithmetic makes it possible for him to continue to use these skills towards his active participation in the life of his community"

To us the ideas of FCUBE and FLP were very positive and well intentioned. But why did Ghanaians fail to go along with the then Government on this program? The answer is the over politicization of important national issues. The policy was formulated and implemented in a mad haste; otherwise we would not have acted before thinking. How on this earth could the policy makers think that we could implement such reforms without the requisite retraining or at worst the appropriate orientation of our teachers, without the provision of relevant teaching and learning materials and without a highly motivated teacher-workforce? The policy also lacked foresight and vision into the future. Was it a deliberate decision on the part of the policy makers to gloss over the need to incorporate ICT into the then reformed curriculum?

If we digressed into our recent past it is exactly because we as a nation must learn from our past mistakes, if we ever want to move a step ahead in our development effort. Let us not put the cart before the horse this time round! We need to explain the tenets and educate the population on the relevance of ICT in our time. It is relieving to note that the National Commission on ICT Policy has adopted a consultative approach in collating the views of not only all stakeholders but also of the general public. This approach certainly would base the policy on informed ideas that would be acceptable to all stakeholders.

According to Nikoi (2000)

It is generally said that the quality and way of life of any country largely reflect the proportion of the population that is literate. The higher the percentage of literacy the more technologically, scientifically and economically advanced the way of life of the people. A reading population therefore contributes to creating a prosperous and productive society

We would like to add that a technological literate society, in our present situation ICT literacy and infrastructure at that, is the most valuable resource for our national survival in the information age. Ghana's Vision 2020 plan anticipates that the country will advance technologically, economically (our per capital income moving from 400 UDS to about 2000 UDS) and scientifically by the year 2020. The present talk on this is that the per capita income should be USD1000 by the year 2010. This vision would not be achieved unless we make realistic efforts to address the deficiency of our human resource base now and map out clearly our priorities as a nation. Let us begin to talk less and act more. The game in the global village created by the ICT revolution requires proper planning, and appropriate actions. We must develop the capacity to compete in the arena of globalization. We see clearly that the ICT policy enjoys a wider acceptability than the recent educational reforms but we should not be complacent with this. The policy implementation would require heavy investment of both capital and human resource training. We should take care to ensure that a greater proportion of Ghanaians economically utilizes the ICT facilities; otherwise it would also be a drain on our scarce resources. A phase-by-phase implementation and an integrated approach are therefore needed in this direction.

It is our view that our ICT policy formulation should center on the following issues

- Clear Objectives for the ICT Policy for Ghana
- Appropriate Components of ICT that Need to be Adopted for Ghana
- Manpower and ICT Infrastructure development
- Clear Regulatory and Implementation Guidelines
- Need to Integrate the ICT infrastructure and Coordinate ICT Activities among the numerous Stakeholders
- Funding for the Nation-wide Adaptation and Deployment of ICT
- The Future Projections on the Industry in Ghana

Each of these issues could form a subject of its own, but given the limited space available We shall limit our discussion to the impact of ICT on our society and the need for us as a nation to thoroughly prepare to face the challenges of the information age. It is our belief that the generality of the Ghanaian society still requires this sort of awareness education.

Objectives for the ICT Policy for Ghana

The objectives of Ghana's ICT policy should be based on our developmental aspirations. Let us be informed by our needs rather than be dictated to by technology. Thus we must adopt the technologies that are in consonance with our needs, values, and culture, with the view to empowering the citizens to become more productive, civil, and morally upright. One of the reasons why our society confronts so many unexpected problems is

that we tend to adopt new technologies before considering possible consequences (Rob Kelly, 1982, 386).

Factors such as increased productivity, enhanced efficiency at workplaces and businesses, increased access to relevant global information in governance, trade and new technologies themselves, and improved quality education should guide us all in our quest for ICT capabilities and expertise. The policy should also aim at integrating the ICT infrastructure across the country, lest we waste scarce national resources through the duplications of efforts. As a HIPC nation we have to avoid every form of waste of our scarce resources. We have capable ICT experts now in Ghana who when encouraged and appropriately challenged could help design and implement our ICT infrastructure and tools. The policy should be packaged in a way that would attract the subscriptions of corporate bodies, organization and capable individuals.

We are aware and we laud His Excellency, the President's special interest in the development of the ICT infrastructure of Ghana. That is a visionary move that requires the support of every Ghanaian. Many well-meaning citizens have added their views to this need but very few of them have emphasized the deployment of ICT tools in the education sector. We can buy, adopt and even steal some of these technologies from the developed nations but what good would that be to Ghana in the next five or ten years' time? We need to build our ICT infrastructure on a sound educational system that would ensure our future independence on the so-called developed nations for the transfers of such technologies. We should note that the ICT is not only expensive but also so dynamic that we cannot keep pace with it. Yes, initially we have no choice but to borrow these technologies and train some of our initial experts but our long term plan should aim at empowering our universities, polytechnics, and other institutions to continuously produce the right caliber of workforce that would face the challenges posed by the information based world. We have to start relying on indigenous initiatives and build the needed confidence in our local experts in order to overcome the seemingly perpetual dependence syndrome.

Countries of South East Asia, notably Malaysia, China, Singapore and India took this path a few decades ago. We are sure they are at their present economic and technological level of development because of the vast opportunities appropriate education and reliance on local initiatives opened for them. Some countries in Africa, particularly Uganda, Kenya, Botswana, South Africa and Senegal have taken a bold step in this direction already and they are a step ahead of us. Rwanda just emerging from a civil war has started reaping the benefits of a well planned ICT policy and goal-directed educational plan. Can we in Ghana take clue from these countries?

The Challenges of ICT on Society

The ICT revolution is having a powerful effect on the way people live in society. The computer as a multi-purpose invention is central in this global phenomenon. Computers can be endlessly modified through its programming to guide spacecraft, teach, diagnose patients, search criminal files, draw three-dimensional pictures, talk, generate music, and even operate entire factories automatically. The marriage of computer technology with communications technology gave birth to the much talked about Information Communications Technology or ICT. It is this marriage that has not only extended the

power of the computer but also enhanced communications around the world, making it easier to transact businesses at a level not anticipated a couple of years ago. The uses to which computers are put determine our view of computer as a positive tool or negative one. As ICT gain wider popularity and usage, it may affect our work ethics, our view of the world and also the way we perceive ourselves as human beings. ICT environment may therefore be regarded as a mixed fortune. The impact of ICT is greatly manifested in the realms of increased productivity, expanded mental capabilities of users, changes in the job market, commercial and business transactions, frustration in dealing with computer oriented systems, invasion of individual privacy, and governmental control of society through the use of data banks on individual citizens. We shall look at these issues in the rest of this presentation.

Increased Productivity

The increased throughput attainable through the application of ICT tools has remained as the most important reason for the deployment of computer-based systems. These systems allow people to accomplish more tasks with greater speed and accuracy than they did a couple of years ago. For instance, office secretaries now type, edit, and electronically save files that are more error-proof documents with a word processing station than could be achieved with an ordinary typewriter and manual filing systems. The use of computers and the Internet has made information transmission, retrieval and storage relatively easy and efficient. In recent years, the introduction of teller terminals has allowed financial institutions to handle an increase in number and quality of banking transactions. Similarly, the Airline and hotel clerks with immediate access to flight times and passenger statistics now complete a transaction at a fantastic greater speed than was possible without the aid of a computer system. These are just a few of the areas of our economy that are benefiting from the ICT tools.

ICT Has Extended Our Mental Capabilities

The speed and relative accuracy of computers are exploited to calculate very complicated equations, predict future trends in businesses and physical phenomena, draw three-dimensional animated diagrams and simulate situations that are either too dangerous to carry out in reality or which only our imagination may conceive. Science, medicine and technical research have benefited immensely from the advancement of computer technology. Intriguing new discoveries in these field and approaches in communications, weather forecasting, transportation, and engineering are increasingly dependent on ICT tools.

Changes in the Job Market

This is one area where the impact of ICT is most felt. Manual workers and office managers who carry out routine tasks are being redeployed or replaced because the computer systems can perform such tasks faster, more efficiently, and automatically too. Thus where effective and efficient computer systems have been employed, ordinary typists, filing clerks, mail clerks, shop foremen, mail delivery personnel, printing machine operators, photo developers, office managers, machine operators, typesetters and assembly line workers may be replaced by the computer. The workplace would be more

efficient and perhaps cost-effective but the economic and social consequences need to be addressed in advance of the deployment of such new technologies.

May be we are painting a bleak future for these category of workers. It is not that much bleak as it may sound! Professionals such as medical officers, lawyers (apology to Ghana's Fast Track Courts) and teachers are being challenged by this information revolution. In the medical field computers can be programmed to accept test from interns and nurses, suggest a diagnosis and recommend treatment. Our learned sisters and brothers can now rely on the computer to store vast information of relevant precedent cases that can be retrieved with a cross-index selection program in fractions of a second. That is how quick justice could be done if we computerized our courts! The rather unpleasant adjournments of cases could be brought down to the minimal. Computer Assisted Instruction (CAI) and Computer Assisted Learning (CAL) are important traditional computer mediated systems that teachers and learners could continue to use to achieve instructional and learning objectives across the school curriculum. Multimedia and connectivity with the Internet technology have provided an impetus for online and distance learning systems. This is one area Government must give greater attention to since our rather limited resources and facilities of the conventional school system can no longer cope the increasing demands of higher education. Computers could be programmed to teach any subject. Of course, computers can do this with infinite patience and individual attention. Research workers may also breath a sigh of relief because the Internet and World Wide Web have a vast amount of information that can be tapped for beneficial uses. Sharing of information among researchers and the academia through teleconferencing and other forms of remote interactions are making our work much easier, cheaper and more convenient.

One may wonder whether there is really anything we stand to gain from the introduction of ICT tools in our society. Yes, we stand to gain immensely if we plan properly ahead. The ICT based systems have created new jobs, which the replaced workers may take advantage of. Some of these jobs include computer programming, computer operations, numerical and data control operations and computer maintenance. Displaced workers could retrain for these new jobs. For instance, banks that switched to teller terminals (ATM) have not significantly reduced their clerical staff. This category of bank workers stayed on and learned to use the installed computer systems to perform their jobs. This means that we have to appropriately educate the next generation of workforce to supply a job market that computer technology has made distinctly different. Technologically ill-prepared workers need not be frightened by the prospects of being rendered perpetually unemployed. The apparent slower rate of the change over to new computer systems would allow our society to absorb the few displaced workers into new and satisfying roles. The order now is that the unskilled labour force should be prepared to retrain and sometimes relocate in new workplace environments.

Need to Understand the Notion of GIGO

We sometimes face avoidable inconvenience and frustration through errors related to computer-based systems. Many people receive bills, address labels, bank statements or paychecks with incorrect information. Most of the times the service provider puts the entire blame on the computer. That is certainly a partial truth because the computer can

only be accurate to the extent of the degree of accuracy the input data and instructions allow it. Computers have no reasoning capacity of their own, but they faithfully follow the instruction given by users or programmers to carry out the tasks. The idea of Garbage in Garbage out (GIGO) is a common jargon among ICT experts. The type of problems given above often arises because of a lack of communication between the computer department and the rest of the organization, a programming error or simply by a clerk who may not be conversant with the computer system. Some of the large organizations also hire the services of outside companies to process their data. Invariably, complaints from customers to such organizations may not reach the external company to effect the necessary revisions early enough.

Effective connectivity and normalized Database Management Systems (DBMS) that would provide the customer service department of an organization with computer terminal so that they have access to customers' files would go a long way to reduce such computer system errors. System analysts must be more careful in their program designs. There is also a great need for better-trained computer personnel who can understand the complexities of large computer systems.

The Cashless Society

The deployment of ICT in the banking industry has brought us closer to a situation where physical cash would cease to be a major medium of exchange. Department stores, gas stations, travel agencies, hotels and restaurants now accept a variety of credit cards in the so-called developed economies. The electronic funds transfer has come to ease the difficulties associated with international money transactions. Many Ghanaians have seen the benefits of the services of Western Union, Money gram, and many others in our economy now. Employees' wages could now also be directly deposited into their bank accounts. Electronic funds transfer systems are no good news for thieves and bad accountants, but white colour fraud and computer-theft is gradually gaining currency in our society. Unscrupulous individuals that have access to government documents and individual information often use the Internet for serious mischief. We should guide against this phenomenon!

The future prospects with regard to electronic money is that a single plastic identification card called a debit card would replace a purse or wallet full of physical money. This is no good for pickpockets either! The debit card works this way: when a cardholder of the card purchase an item the cashier keys in the identification number, usually a social security number, and the cost of the item. The electronic cash register, which also acts as a computer terminal, sends a message to the computer in the cardholder's bank. The bank's computer checks the holder's account balance. If the balance is sufficient, the cost of the purchase is automatically deducted from the cardholder's account and deposited into the store's account.

This technology eases business transactions in terms of time and convenience. The over all gain is efficiency in commerce.

The Privacy of Individuals

Government agencies, credit card companies, and large corporations hold large volumes of information on people in databases. This sort of personal information may include

criminal records, evidence of alcoholism, rape, drug abuse, school records, taxes, birth and deaths, marriages and divorces, records of financial transactions and bank accounts, medical data and family relations. The process of such data and information is greatly enhanced by the applications of ICT. Computer based systems offer convenient storage facilities for large volumes of information, which can also be retrieved very efficiently. It is therefore fairly easy for an outside agency or some individual with access to a computer terminal to obtain a hardcopy on anyone they wish, if the centralized data banks are not adequately secured against unauthorized access. Politicians, law enforcement agencies, newspaper reporters or blackmailers could use such information on individuals to ruin their reputations. The misuse of such information on the individual could also lead to a loss of a job by publicizing personal data.

Another form of the invasion of the individual privacy may involve the indecent materials on the Internet. Regular users of the Internet may encounter mail messages on unsolicited commercial advertisements, pornographic images, and computer scams. Unless adequate security regimes are adopted, the private email discussions of users are also subject to unauthorized intrusions by other users of the Internet. A more disturbing phenomenon currently gaining unsavory reputation is the misuse of cellular phones at public places. Some of these cellular phone owners invade the privacy of others by forcing them to listen to their conversations, which have the grave potential of distracting attention at meetings, lectures, and other formal public gathering. The menace of the cellular phone users is just as bad as cigarette smokers' to the general public. These are some of the inconveniences we have to put up with in this information age. Can we legislate on the appropriate use of these gadgets? What can we do about the growing menace of Internet and other forms of electronic fraud?

Components of ICT that Need to be Adapted for Ghana

Our integrated ICT plan should focus on the business, trade and investment, health, industry, and education sectors of the economy. The development in these areas depend directly on an effective sustainable ICT infrastructure that is enabling enough for our entrepreneurs and administrators to take advantage of computer mediated systems and telecommunications technology. In this case, computer based connectivity and efficient telecommunications networks should be given greater attention. We should adopt the various forms of Internet connectivity, basic normal dial-up system, dedicated leased lines, fibre-optics networks, digital subscriber lines, radio and satellite connectivity, in an integrated form that would meet the needs of the various sectors and localities. The benefit of the deployment of such an integrated connectivity would be reliable access to local and global information at any time and from anywhere. The provision of reliable and adequate power supply as an allied industry cannot be over emphasized. This sector therefore needs urgent attention, if our efforts at utilizing ICT tools are to bear any fruits.

Manpower Development and ICT Infrastructure

Ghana already abounds in technical expertise in the telecommunication industry. Greater attention should now be focused on Information Technology and computer hardware and software engineering. The need for both hardware designers and software programmers to develop and sustain our local ICT initiatives is so critical now. We therefore have to

empower our universities and polytechnics and other communication related institutions to train a new generation of ICT graduates for Ghana. Perhaps, initially we may have to train a good number of our university dons, who would in turn be enabled to train our youth locally. The universities would have to engage in active collaboration with the ICT industry to tackle this sort of manpower challenge. There are countless native Ghanaians outside the country who have acquired greater heights in this industry. How could their expertise be tapped for the development of mother Ghana? The Chinese, Malaysians, Singaporeans and Thais all have used their citizens abroad to help nurture their local ICT industries and infrastructure. Their governments have also made concrete and deliberate efforts to sponsor capable citizens for ICT training abroad. I think Ghana has to start looking in this direction too. In this era of golden business opportunities we should encourage both internal and external investors in this sector of our economy. Serious investors will always look for only ICT literate workforce, dependable and affordable power supply, reliable and effective judiciary and reliable communications systems.

Conclusion

We are in deed in an era that requires that every developing nation make serious efforts to bridge the digital divide between the rich north and the poor south. The dictates of the globalization and trade liberalization are such that our capacity to compete effectively in the international arena depends on our access to quality information and knowledge. The key to open this resource is an integrated ICT infrastructure. The challenges of this era are real and constitute a mixed fortune for developing nations such as Ghana. This is because we depend so much on an unfair international trade liberalization that unjustifiably favours the industrial developed nations. Unless we take advantage of the vast opportunities that ICT offers us now, we are not likely to make any serious progress in our fight against disease, ignorance, civil strife and abject poverty plaguing our society today. If we tackle this issue with reasoned plans and concerted efforts, we are likely to leapfrog some of the developmental stages these developed nations had had to pass through. The challenge is for our government, technocrats, labour force, universities and other research institutions, and business corporate bodies to unite their efforts now to push us across the digital divide. The challenges posed by the information and knowledge based economies require us to restructure our education system and business practices.

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We reap what we sow. Teachers not teaching or learners not learning mathematics?

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Abstract.

Children are entrusted in the hands of teachers who have gone through, at least, a three-year professional training programme and are certified to teach. This paper examines the mathematical conceptual understanding of teachers. Since one cannot give what he or she has not, the paper attempts to examine the sort of mathematical concepts sown in the minds of the young children by their teachers. The study shows that wrong concepts are sown in the minds of children right from the beginning because most teachers themselves do not have clear understanding of the concepts they teach. The study suggests that the mathematical output of our children is direct reflection of the mathematics concepts taught. It argues that until the teachers gain full mastery of subject matter they teach, they will not be in the position to help learners make significant gains in their mathematical pursuits.

Introduction

The fundamental objective of mathematics education is to enable learners understand, reason and communicate mathematically, and solve problems that might confront them in their daily life. Cognisant of the important role mathematics plays in the overall personal and intellectual development of the individual, governments all over the globe make conscientious efforts to make mathematics learning easy and to popularize its study in their countries. In Ghana for example, Mathematics and Science Clinics are organized at the district, regional, and national levels aimed at demystifying the wrong notion that mathematics and Science are for a particular class of people. Mathematics is also given priority in the school curriculum. It is made a core course of study at the pre-tertiary level and takes about 25% of the instructional time. Mathematics is perceived as an interrelated structure of ideas, principles, and processes and in

teaching, its connections among basic concepts should be established to make learning easy for pupils (Reys, et al, 1998). Those who are supposed to teach mathematics at the foundation level are therefore expected to be well grounded in both subject matter and pedagogical content. Basic school teachers need knowledge of facts, skills and concepts described by the national curriculum. The knowledge of facts, concepts and explanatory frameworks for guiding inquiry, referred to as substantive knowledge (Carre, 1993), is basic requirement for teaching children. Teachers also need a sound understanding of the mathematical processes, conceptual relationships and their applications in teaching and identifying errors. Indeed, the identification and remediation of learners' errors involves the application of mathematical procedures and the ability to see how the learner understands the subject (Carre and Ernest, 1993). Of course the reason for this argument is not far-fetched. Can we emphatically say that all the teachers in the basic schools are well grounded in these content domains? To answer this question, let us examine the following demonstrations of basic school teachers understanding of some basic concepts in mathematics in a study conducted in the year 2000.

The study involved 200 practicing teachers from all over the country who came for a pre-entry programme into the University College of Education, Winneba.

Table1 Performance of teachers in the basic concepts

<i>Concept</i>		<i>Test Item</i>	<i>Correct Response</i>	<i>% Score</i>
Place Value	1b	What is the value of 2 in 314. 235?	42	20.89
Algebra	2	31 beer bottle tops covered the entire length of a meter rule. What is the diameter of a bottle top? Leave your answer correct to 4.s.f	22	10.95
Integer		Evaluate:		
	6	(i). $\frac{0}{4} = \dots\dots\dots$, because $\dots\dots\dots$	61	30.35
		(ii) $\frac{6}{0} = \dots\dots\dots$, because $\dots\dots\dots$	3	1.49
		What is the multiplicative inverse of -5	49	24.38
Fraction	5	What is the difference between a common fraction and a decimal fraction?	6	2.98
Measurements	9	The Volume of a container is 25cm^3 , what is its volume in litres?	40	19.90
	10	The mass of an object is 100kg, what is its mass in milligrammes?	45	23.49

Source: Nabie, Anamuah-Mensah, & Ngman-Wara, (in press)

These results amply demonstrate poor content knowledge in these fundamental concepts. Meanwhile between 61 and 68% of the teachers perceived the above concepts not difficult. Reasons they gave for some of their responses strongly manifested a high degree of conceptual difficulty in the concepts many perceived very easy. For example, in item 5 we have responses such as:

- "A decimal fraction is expressed in either tenths, hundredths, thousandths, etc. whereas a common fraction cannot"
- "A common fraction is expressed as a ratio of two whole numbers but a decimal fraction is expressed as a base ten numeral"
- "The common fraction involves a division sign in the form $\frac{a}{b}$ but there is a point in decimal fraction. e.g. 0.125"
- For many teachers, $\frac{4}{0} = 4$ for item 6i with the following reasons:
 - "you have 4 things and divide it among zero people the result will still be 4",
 - "no one is sharing the 4 with that particular 4"
 - "it is indiscrete"
 - "4 divided by zero children you still have your 4 standing".

In item 6ii, the following reasons were given to support their responses:

- "Number 6 has nothing to share with" ,
- "0 oranges cannot be shared by 6 people",
- "six people sharing *nothing gives nothing*" ,
- "if you have *nothing* and you divide into six you will have zero" (the italicised is our emphasis).

Similar questions were asked a group of teachers pursuing a pre-entry programme into the university in the year 2002. Teachers submitted their responses when they felt satisfied that they had done justice to the problems just as in the first study.

Some of their responses are as below:

Question: *What is the difference between a common fraction and a decimal fraction?*

Responses from teachers:

1. "The difference between a common fraction and a decimal fraction is that with common fraction the numerator is less than the denominator. E.g. $\frac{a}{b}$, $a < b$.
2. Whiles with decimal fraction the numerator can either be greater, less or equal to the denominator"

3. "the difference between a common fraction and a decimal fraction . *An example of a common fraction is $\frac{100}{100}$. Decimal fraction is $\frac{100}{200}$. Common fraction has a denominator as 1 e.g. $\frac{100}{1}$. Decimal fraction has a denominator more than the numerator"*
4. "A common fraction normally gives a whole number or value while a decimal fraction gives a proper or improper fractions"
5. "Common fraction is the inverse of decimal fraction and vice versa"
6. "A common fraction has no point but a decimal fraction has a point"
7. "Common fraction = Decimal fraction"
8. Any number divided by 1 e.g. $\frac{2}{1}$, $\frac{4}{1}$ etc.. in this, it is any number divided by number other than 1. E.g. $\frac{1}{2}$, $\frac{4}{3}$ etc."
9. "A common fraction is a fraction which has a numerator and a denominator e.g. $\frac{2}{3}$ and decimal fractions are fractions with points on both the numerator and denominator"
10. "Fractions belong to rational no and real numbers but decimal no belongs to only real no and not rational numbers"
11. Common fractions are written in the form of numerator divided by a denominator thus $\frac{2}{3}$. Hence it is written vertically; also normally the numerator is smaller than the denominator. Whereas decimal fractions have numerators greater than denominators e.g. $\frac{6}{4}$. Hence the result can be written in decimal form e.g. 1.22 etc in horizontal form.
12. "Decimal fraction is where the denominator of the fraction is bigger that the numerator and the common fraction is where the numerator is bigger than the denominator"

For the 2002 group, item 6 (i & ii) were reframed in context though the solution process would end with the same operations. In particular, this group of teachers was asked to find the gradients of the lines joining

(i) A (2, -1) and B (2, 6)

(ii) D (2, 2) and D (-4, 2)

after they had treated gradients and equations of lines. Basically these questions were meant to explore teacher's interpretation of division involving zero.

Below are some of their solutions:

Student A:

(i) Formula= (ii)

$$\begin{aligned}\frac{y^1 - y}{x^1 - x} &= \frac{-1 - 6}{2 - 2} = \frac{-7}{0} \\ \therefore y - y_1 &= m(x - x_1) \\ &= y - (-1) = -7(x - 2) \\ &= y + 1 = -7x - 2 \\ &= y = -7x - 2 - 1 \\ &= y = -7x - 3\end{aligned}$$

$$\begin{aligned}\frac{y^1 - y}{x^1 - x} &= \frac{2 - 2}{2 - (-4)} = \frac{0}{-6} \\ y - y_1 &= m(x - x_1) \\ y - 2 &= -6(x - 2) \\ &= y - 2 = -6x - 2 \\ y &= 2 = -6x - 2 \\ y &= -6x = 2 - 2 \\ y &= -6x = 0\end{aligned}$$

Student B:

$$\begin{aligned}\text{(i)} \quad \frac{y_2 - y_1}{x_2 - x_1} &= \frac{6 - (-1)}{2 - 2} = \frac{7}{0} = 0 \text{ Ans.}\end{aligned}$$

$$\begin{aligned}\text{(ii)} \quad \frac{y_2 - y_1}{x_2 - x_1} &= \frac{2 - 2}{-4 - 2} = \frac{0}{-6} = 0\end{aligned}$$

The responses of both groups to the items in essence are similar. The common trend is lack of understanding of the basic concepts. This has serious consequences on mathematics instruction at the basic school level.

Most of the algebra work at the basic school level involves number and number notation. Number notation helps us to see how number is organized, what structure it contains, and how it is related to other numbers (Williams and Shuard, 1982). It forms the basis for working with and understanding further work on number and number operations. The inability of many teachers to correctly respond to the question on place value suggests that a significant proportion of classroom teachers lack a clear understanding of number notation. The implications for classroom instruction are anybody's guess.

As teachers, we know very well that the four basic operations (addition, subtraction, multiplication, and division) are closely related. In particular, multiplication and division are inverse relations so as addition and subtraction. Also, multiplication can be defined in terms of addition (repeated addition) whereas division may be defined in terms of subtraction (repeated subtraction).

The answers and reasons given by teachers to support items 6(i) and 6(ii) demonstrate teachers' misconception of the number zero (0). Zero (0) is a cardinal number and represents the number of elements in an empty set. It is with the inclusion of zero that the

count of every set can be symbolized. From the responses, it is clear that some teachers think of zero as ‘nothing’. If teachers think of zero this way then it is a clear manifestation that the importance of zero as a symbol for a cardinal number and with which the count of every set can be given a symbol (Devine, Olson, and Olson, 1991) is not understood.

By the definition of division, $\frac{a}{b} = c$ if $a = bc$. This means that $\frac{0}{4} = 0$ because $0 = 4 \times 0$

and $\frac{6}{0}$ is undefined or infinity or impossible because we cannot find any number x such that $6 = x \times 0$. This is the algebraic argument for one who understands the inverse relation between multiplication and division. On the other hand if we think of division as repeated subtraction, then $\frac{10}{2}$ can be put in real situation as, if there are 10 mangoes to how many children can I give two mangoes each? We may proceed to do the subtraction as below:

Quantity	Take away two	Child	
10	2	1st	$10 - 2$
8	2	2nd	$8 - 2$
6	2	3rd	$6 - 2$
4	2	4th	$4 - 2$
2	2	5th	$2 - 2$
0			

So after five subtractions, we have zero mangoes remaining and the exercise is complete.

Therefore $\frac{10}{2} = 5$ and that is correct.

Similarly, $\frac{6}{0}$ can be treated as above. That is if I have 6 mangoes to how many children can I give 0 mangoes each?

Quantity Remaining	Take two	Child
6	0	1 st
6	0	2 nd
6	0	3 rd
6	0	4 th
6	0	5 th

6	0	6 th
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You observe that no matter how many times (100, 10000, 10000000000, ...) the operation is carried out, the number of mangoes remains the same. Therefore the number of times is infinite.

When we write for example $\frac{1}{2} = 0.5$, it means the expressions are equal. The left-hand side is a common fraction while the right-hand is a decimal fraction. This simply means that a common and decimal fraction are different representation of the same and are therefore equal. This basic concept is not common among teachers as indicated by their reasons above.

Conclusion

The above presentation indicates that bad seeds were sown during the teacher preparation process and hence we reaped what we sowed-mathematically “stunted” pupils. Our vision for our children to attain numeracy by the end of their basic school years is in limbo. Since the implementers of the curriculum are stunted in the relevant basic concepts that will lead to the goals of the curriculum.

Recommendations

We are of the view that these deficiencies stem from the teacher preparation process.

We therefore call for a review of the Initial Teacher Training College (ITTC) mathematics curriculum in both its content and pedagogical content knowledge.

The intensity and focus of the mathematics teacher preparation process should be seriously re-considered.

Also, in-service training programmes on both content and pedagogical content knowledge of the relevant basic concepts should be periodically organized for basic school teachers throughout the country.

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The Effect of Preschool Education on Children's Number Competence at the Start of Formal Education

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Abstract

The study is an investigation into the effect of pre school education on children's number competence at the start of formal education. The purposive sampling technique was used to select a sample size of sixty respondents made up of thirty girls and thirty boys. Qualitative methods were adopted for collecting data for the study. The major instruments used for the collection of data were clinical interviews and observation. Pupils were given various tasks involving counting and their most advanced behaviours with numbers were observed. Data collected were categorised into common themes including subitizing and analysed. Results of the study include the fact that children are able to recognize the number of objects in a small collection, usually up to five, without actually counting (subitizing). Children starting formal schooling try to show respect for the counting principles. Many pupils did not rely on counting to make equivalent sets. Finally, the study revealed that there is a spectrum of pupils in BSI bring into for formal school. It is therefore being recommended that teachers use strengths and not the weaknesses of girls to positive attitudes towards mathematics. Again, the concept of subitizing appears to be a new concept among teachers. It is therefore recommended that activities are designed to encourage and develop this imagery skill in the lives of children.

Introduction

Naturally, the family is the greatest influence on the child's growth and development. However, the structure of families has changed over the last few decades (Barnes and Koford 1987). In today's world, the traditional family consisting of a mother who is a homemaker and a working father is less common. In many families, both parents have to work in order to make ends meet. Besides, divorce with its concomitant single parenting is on the increase

(Hetherington 1979) and many women have to single-handedly care for and support their children's needs. Maymi (1982) claims that two-thirds of all women in the labour force are either single parents (i.e. widowed, divorced or separated) or married to husbands whose income levels are very low.

In most parts of the world, particularly Africa, some women take off from their homes as early as 4 o'clock in the morning, when their children are still in bed, in order to engage in one form of work activity or the other. Children are therefore left at the mercy of house-helpers and neighbours, or in extreme cases they are left on their own. In advanced countries, children in this situation are left in the care of caregivers or attendants in preschools because it is a very serious crime to leave children at home on their own without attendants.

It is believed that children who are left on their own lack many social and cognitive skills that may be provided in the formal preschool environment (Steinberg 1986). Experiences gained from the preschool environment may also have the potential to compensate for the lack of parental guidance. Unguided and unsupervised children might get into trouble and may even engage in delinquent behaviour. Studies have shown that parental monitoring deters children from engaging in delinquent activities (Steinberg 1986).

Preschool education is any type of formal education given to cover children between the ages of eighteen months and five years. This is the period when so many social attitudes and personality characteristics are developed. In the preschool, children are introduced to the kinds of experiences that will give them a good foundation for what may later be learnt in the formal basic or primary school. Concern for the care and education of young children under the age of six did not develop over night. Actually, it has evolved over the centuries (Kaplan 1986).

The premise that a child's beginning or early years are the most crucial has been expressed countless times in various ways and in different cultures (Caplan 1983). Since the days of the advocates of preschool education, the growth in enrolment and the attendance of nursery schools have been very impressive (Kaplan 1986). Kaplan argues further that the percentage of children attending preschool increases with age. The United States of America Bureau of the Census (1985) reports that most five-year old children attend kindergarten and the numbers of three- and four-year olds attending preschools have increased significantly over the last two decades. The need for many women to work to supplement the family income has accounted, to a large extent, for these increases. In other cases, parents worry that unless their children get preschool education, they will enter elementary school virtually at a disadvantage.

There are many approaches to preschool education. Some emphasise the importance of social skills and emotional development. In such preschools, their programmes include story telling, listening to music, looking at art works, taking trips and encouraging cooperation and sharing (McClinton and Meier 1978). Other preschools are more cognitively oriented. In both persuasions, the young child has the opportunity to learn to share objects, experiences, and feelings with other individuals outside their own family members. Generally, preschools are able to set targets of children's progress and accomplish their

purposes. Children who attend preschool programmes are usually more socially adjusted, self-assured, curious, independent and persistent on tasks. They are also goal directed, cooperative and friendly (Clarke-Stewart and Fein 1983). Washington (1985) adds that children at the preschool level learn to work and play independently, become more able to accept help and direction from adults and caregivers, sharpen and widen their language skills and develop the ability to channel inner destructive impulses properly.

Researchers not only demonstrate the importance of social interaction, the self-concept, and self-esteem in their own right, they also show that these attributes have some influence on academic achievement. Educators are therefore interested in the social and personality development of children because it is believed that helping children to build positive views of themselves and good interpersonal relationships mediate between the learner and what is achieved at formal school. It is also believed that these social and personal development factors are better provided and addressed in preschools especially with children who have poor socio-economic background.

Unfortunately, while research on preschool education has received considerable attention by educationists since the late 1970s (McClinton and Meier 1978) and the 1980s (Caplan 1983; Minuchin and Shapiro 1983; Kaplan 1986), little empirical studies have been done in certain parts of the world to ascertain the advantages and disadvantages of preschool education. Also, there is no evidence of how the attendance, or otherwise, of preschool influences children's competence in early number. It is believed that preschool education lays the foundation for formal education. Most education reforms the world over talk about preschool education as the starting point of formal education yet this level has been left on the shoulders of private individuals and organisations. It appears some governments are not fully committed to the ideals of the preschool segment of the educational sector. It is in the light of this that we desire to investigate the effect the attendance of preschool has on children's number competence.

Methodology

Qualitative methods were adopted for collecting data for the study. The study involved sixty pupils made up of thirty boys and thirty girls from two primary schools in Winneba in the Central Region of Ghana. The pupils were just beginning their formal education in Basic Stage 1 (BS1). While some of them had attended preschool others had not. The sampling of pupils was done on purpose, to include pupils whose parents belonged to different levels of socio-economic and educational backgrounds.

Instrument

The major instruments used for the collection of data were clinical interviews (Piaget 1928) and observation. Pupils were given various tasks involving counting and their most advanced behaviours with numbers were observed. As pupils went through the tasks they also answered questions as a way of demonstrating their intentions.

The focus of the study was intended to find out the effect of preschool attendance on pupils' counting, addition and subtraction competence. With this in mind, pupils were asked to count a number of objects ranging from four to nineteen, arranged in various forms on several trials. Furthermore, activities that involved hidden objects were carried out to find out how pupils attempted to add and subtract small numbers.

Each pupil went through a series of different tasks, which lasted for about twenty-five minutes. The tasks involved subitizing and counting of objects. Subitizing is the ability to look briefly at a set of objects and then tell the number of objects in the set without actually counting. The numbers of objects ranged from three to twenty and were presented in different arrangements. The tasks also involved addition and subtraction with some of the objects covered.

The tasks involving subitizing was designed to ascertain the extent to which children have developed imagery skills. In this task, pupils were shown a set of objects for a brief period of approximately 4 seconds and then asked to tell the number of objects in that set. The number of objects ranged from three to as many objects as the pupil would find difficult to tell correctly.

The tasks involving counting of objects were designed to find out whether pupils obeyed the counting principles. The addition and subtraction tasks were also designed to find out the pupils most advanced strategy for solving such tasks.

The pupils' clinical interviews were video-recorded since the tasks involved the use of counting materials and actions. Maykut and Morehouse (1994: 112) confirm that, "more recently, the use of video-tape has found a place among the collection of data gathering strategies available to researchers". The videotape allowed us to capture pupils' gestures and other non-verbal actions, such as indicating acts used in counting, that were displayed by the pupils, but which were important to the study. The videotape also allowed us to view and re-view pupils' responses over and again for further analysis. The pupils were aware that they were being video recorded, however, as soon as they got absorbed in the interviewing process they appeared to have forgotten out the presence of the recorder.

Data collected were categorised into common themes and analysed. The common themes include subitizing, counting of objects including indicating acts used, the use of counting as a tool and socio-economic background of pupils. Under these common themes comparisons were made according to whether pupils attended preschool or not. The gender dimension was another issue that was considered.

Results and Discussion

The discussion brings together counting, addition and subtraction skills demonstrated by Basic Stage 1 (BS1) pupils. These skills were analysed for their central themes and implications.

The breakdown of the pupils by their parents' educational background, sex and attendance of preschool is presented in Table 1.

Table1 Distribution of pupils by parent's educational background, sex and preschool attendance

Parents' Educational Background	Preschool		No Preschool		Total
	Boys	Girls	Boys	Girls	
Unschooling	2	1	3	4	10
Elementary	3	2	4	5	14
Secondary	2	3	2	3	10
Post-Secondary	5	3	0	0	8
University	4	5	0	0	9
Post-Graduate	5	4	0	0	9
Total	21	18	9	12	60

A study of Table 1 shows that all the 21 pupils who did not attend preschool have parents who are either unschooled, had elementary or secondary education. More girls than boys were denied preschool education. All the pupils including 12 girls whose parents had had post-secondary and university education had preschool education. The data further revealed that out of 10 pupils whose parents were unschooled only one girl and two boys had preschool education. For the 14 pupils whose parents had elementary education as many as nine including five girls did not attend any preschool.

The ages of the pupils in the study ranged between five years and thirteen years. The distribution of pupils and their ages is presented in Table 2.

Table 2 Distribution of pupils by age and sex

Age	5	6	7	8	9	10	11	12	13
Number of Girls	4	7	5	3	2	2	3	3	1
Number of Boys	5	8	6	4	1	2	1	2	1
Total	9	15	11	7	3	4	4	5	2

The data shows that 19 girls and 17 boys in BS1 were aged 7 years or older. More girls than boys were older than 9 years of age.

The results of the study are based on the following themes:

- Subitizing.
- Pupils' respect for the counting principles.
- Pupils' knowledge of counting and number.
- Home background and pupils' competence.

Subitizing

Children are able to recognise the number of objects in a small collection, usually up to five, without actually counting (Cooper 1984; Strauss and Curtis 1984). This is referred to as subitizing. Fuson (1988) also contends that subitizing is a means by which a number word is assigned to a cardinal situation. Observing for a few seconds, a collection of objects and correctly telling the number of objects, without counting, demonstrates children's ability to subitize. Pupils in the study demonstrated various levels of subitizing.

The study revealed that the pupils could tell number of objects in a collection without counting. Most pupils were able to answer correctly that there were four objects in the set showed to them. There was an interesting case of a six year-old pupil who attended preschool. This pupil had given the correct response of 'four' when she was shown a set of four objects. When she was shown a set of six objects, she looked intently at the interviewer for a while and then said, "Let me see it again, I did not see it well". When she was shown the set of six objects again she looked aside for some time and then said "five or six". Finally, she said "six". She was then asked to explain how she came by the correct answer. To this she answered thus, "I made a picture of the objects in my head and counted to get six". The response of this girl suggests the possibility that children do not just say number words when shown sets of objects. They try to make mental pictures of how the objects are presented to them and then estimate to determine the correct number of objects in the set. Children's ability to give the correct number word to the set of objects depends on the number of objects in the set. It is, thus, easier for children to subitize correctly if the objects in the set are few. However, this ability does not come all of a sudden. It is developed as children encounter tasks that provide them the opportunity to hold images of the arrangement of objects in their minds and count them. Twelve of the pupils were able to subitize correctly a set of seven objects. All these pupils were those who had attended preschool and have educated parents who have exposed them to such tasks. One such pupil looked at the set of seven objects shown to him, made a representation with his fingers and said "Seven". In fact, this pupil used this strategy to answer correctly on every trial. It is worthy to note at this point that the tasks on subitizing were not presented in any specific order. This was to prevent the pupils from pre-empting the next answer.

The data from the study, however, revealed that there was no clear difference in the extent to which children of various ages could subitize. For example, an eleven year-old boy, who did attend preschool, could not subitize correctly any other set except that containing three objects, but a five year-old girl, who had attended preschool, was able to answer correctly when a set of six objects was shown to her. Initially, it was our assumption that the older a pupil is the better his or her ability to subitize, however, the study proved us wrong. The data revealed that whereas some six year-old pupils were able to respond correctly with sets of seven objects, some ten, eleven, twelve and thirteen year-old pupils could not subitize correctly beyond sets of five objects. The data obtained further appeared to suggest that the girls did better in subitizing than their male counterparts. For instance, most of the five year-old pupils who were able to subitize correctly for the set of six objects were girls.

Analysis of the data revealed that all those who subitized correctly for sets of seven objects attended preschool. Also, all the younger pupils (i.e. the five and six year-olds), most of who had attended preschool were able to subitize correctly when they were shown sets of five and six objects. Older pupils who did not attend preschool were unable to subitize correctly when sets of four or more objects were shown them.

Pupils' Respect for the Counting Principles

Nunes and Bryant (1996) have noted that when children begin to count they learn a system, which is partly an expression of universal laws about number and partly a pack of convenient but arbitrary conventions. Children have to struggle with the act of counting itself. In fact, they have to remember the number names and obey certain logical principles. In order that children understand what they are doing when counting a set of objects, they need to obey these logical principles. Gelman and Gallistel (1978) have identified five counting principles, three of which they called *how-to-count* principles. These are the one-to-one, the stable-order and the cardinal principles.

The case study evidence revealed that children starting formal schooling try to show respect for these how-to-count principles. In their study with very young children, aged between 3 and 5 years attending a Demonstration preschool, Gelman and Gallistel (1978) concluded that children as young as three years of age have an intention to count correctly but in the process, however, they make mistakes. In our study, which involved pupils who have just been enrolled into BS1, with ages ranging from five to thirteen years, there was evidence that a good number of these pupils tried to show respect for the rules for counting. Each pupil in the study was asked to count sets of objects. These sets contained objects ranging from five to twelve. The objects were displayed in different arrangements – straight rows, circular, triangular, irregular and in a heap.

For instance, a five year-old girl was presented with a set of six objects displayed in a row and asked how many objects were there. The girl counted each object once and assigned one number name to each till she got to the last object. After counting the objects she was asked again, "How many objects are they?" She now said, "Six". For counting each object once, giving each object one number word and taking the last number word as her answer showed that she was obeying the three how-to-count principles.

It was expected that the older pupils would show more respect for the how-to-count principles but there were cases where pupils, who did not have formal preschool education, could not obey these principles. For example, a thirteen year-old boy could not count properly sets of objects more than five. When seven objects were displayed in a row and this boy was asked how many objects were there, he just recited hurriedly "one, two, three, four, five, six, ten". He behaved in this manner in three trials for seven, six and eight objects. Another pupil aged eleven years could not count even a set of three objects displayed in a row. He just murmured some meaningless words. The words used by this boy were not consistent on any two successive trials. There was a nine year-old girl who was able to count ten objects but could not count sets containing more than ten objects. When she was presented with twelve objects in a row she

counted correctly up to ten then continued, “twelve, twenty”. She found it difficult to count consistently in the conventional order of numbers from eleven to twenty. When she was asked why she could not count beyond ten, she said her elder sister had taught her to only count to ten. It could be argued that this girl’s inability to count sets of objects larger than ten was due to the fact that she did not yet know the vocabulary for numbers between ten and twenty. When a seven year-old boy was presented with five objects to count he just recited some number words and finally said “twelve”. In fact, he ended all his count with the number word ‘twelve’. This particular boy could not count at all. He did not obey the how-to-count principles and even appeared not to know the number names in the local language. All these pupils who had difficulty in counting properly did not attend any preschool and were just coming to formal school straight from home. The five and six year-old pupils, who had attended preschool, did not have any difficulty obeying the how-to-count principles. These children also knew the number names from one to twenty. Apparently, they had learnt them at the preschool.

It was anticipated that age would influence the pupils’ counting competence, as Piaget (1965) indicates, however, evidence from this case study showed that the older pupils, who knew how to count did not exhibit any skills different from the younger ones.

The study also revealed that generally, most of the girls in the sample obeyed the how-to-count principles. For instance, whereas the five year-old girls counted very well, by obeying the three how-to-count principles, boys aged seven and thirteen years could not count properly.

When given objects to count, children use certain representations to assist them to count more accurately. Children count two types of objects as they go through the process of counting. These are movable and unmovable countable items. The representations or actions children make in order to count properly are described as indicating acts. Nunes and Bryant (1996: 26) suggested,

one extremely effective way of ensuring that you are respecting the one-to-one principle when counting movable objects is to move to one side those that you have counted already. If children do adopt this strategy spontaneously they definitely do understand the need for the one-to-one principles.

Evidence from the study revealed that the pupils used a wide range of indicating acts, most of which enabled them to obtain the correct number of objects to be counted. Indicating acts used included pointing at objects, nodding the head, touching objects, fixing eyes on objects and moving objects. It was clear that pupils, who had attended preschool, used the indicating act that they felt would enable them count accurately. On the other hand, those who did not attend preschool even though tried to respect the principles made errors of omission or commission when presented with objects displayed in circular form and in a heap. Some of the older pupils, who counted properly, especially the girls, just gazed at the objects and gave the answer. They only moved objects to count when the objects were many and some were not in full view. Among all of who did have formal preschool education, the girls showed more maturity in their counting than their male counterparts.

Pupils' Knowledge of Counting and Number

It is not enough for children to just know how to count. It is equally important they also demonstrate their knowledge of counting by using the skill in desirable situations. This aspect of the pupils' knowledge of counting is worth discussing because as Nunes and Bryant (1996) put it, "we cannot be sure that children understand the counting system unless they know how to use it properly" (p. 30). Nunes and Bryant (1996) further explained that it is possible that a child can count by respecting all the logical principles and still not understand the nature of the numbers whose names he or she has learnt so proficiently. Hence, if a child is able to demonstrate the use of counting in the solution of a particular problem, it could be reasonable to conclude that he or she has an understanding of the counting process.

The study revealed that many pupils did not rely on counting to make equivalent sets. In the study, the pupils were to take from a heap the same number of objects as there were in a given set. A few pupils just collected any number of objects and placed them in a row beside the given set. Others made a one-to-one correspondence, by matching one object from the heap with each object in the given set. Only seven girls and three boys in the sample used the act of counting to make equivalent sets. A five year-old girl, who had formal preschool education, was presented with a set of six objects and was asked to take from a heap the same number of objects as there were in the given set. After counting the six objects in the given set she counted another set of six objects from the heap. The most predominant strategy used by pupils in the sample for making equivalent sets was matching. By this strategy, each object in the given set is matched with one object from the heap. Most of the five and six year-olds, apparently due to activities they went through at the preschool, used matching to make equivalent sets. Some of those who did not have preschool education could not make equivalent sets by any means. For instance, a thirteen year-old boy was given a set of six objects and asked to make an equivalent set from a heap of objects. He counted the given set to know that they were six yet he collected nine objects from the heap as a set equivalent to the set of six objects. A seven year-old girl was also presented with a set of six objects and was told to make an equivalent set from the heap. She counted the given set and knew that they were six yet collect only two objects from the heap. The behaviour of such pupils could not be explained, and why they could not use matching is not clear.

Home Background and Pupils' Competence

Generally, all the pupils from well-to-do homes attended pre-school prior to their coming to start formal basic education. Well-to-do, as used here refers to people in the society who are educated, working and earning a good income or enough money to live comfortably. In such homes, children have access to television and radio programmes, books, toys and games, and have parents or guardians who show concern in their children's academic progress. The pupils who did not attend preschool at all before the start of basic education were from poor homes, in which case their parents or guardians could not afford the fees charged at nursery schools. However, there were pupils who were not from well-to-do homes who

also attended preschool. The study revealed that the pupils from well-to-do background showed more competence in counting and in the solution of addition and subtraction tasks. Most of the pupils who were able to subitize correctly larger sets of objects shown them were pupils from well-to-do homes. Apparently, this success might be due to the fact that they were exposed to activities in this direction, as most of such pupils have toys and materials that promote imagery skill. Here, it is realised that for pupils to be more successful in school they need both pre-school educational experience, and a home background that supports more formal school concepts, language and ideas.

The study revealed that there is a spectrum of competencies and experiences that pupils in BS1 bring into formal school. There were pupils from different socio-economic backgrounds and pupils who attended preschool and those who did not attend preschool.

Suggestions and Conclusion

The study revealed that in an average public Basic Stage One (BS1) classroom there is a wide range of pupils' ages with the youngest being just a little over five years and the oldest being over ten years. Indeed some are about twelve or thirteen. The analysis of the data revealed that the performance of these five year-old pupils was as good as the performance of the older pupils.

Meanwhile, according to the education system in many countries, children should start formal basic education at the age of six years. In some schools even if the five year old is good enough to be in BS1, he or she has to wait until the attainment of age six. It is our view that affected governments revise this policy and allow children to start school at the age of five years.

The analysis of the data also revealed that the girls in the same age group demonstrated more sophisticated skills and abilities as compared to the boys. However, it is common knowledge that girls develop a lot of dislike for mathematics as they move into higher studies in school. In this regard we recommend that teachers use the strengths and not the weakness of girls to encourage them to learn and develop positive attitudes towards mathematics. Another skill that teachers and educationists should focus on in order to assist children's imagery is the ability to subitize. The concept of subitizing appears to be a new concept among teachers in some developing countries. It is therefore suggested that activities are designed to encourage and develop this imagery skill in the lives of children.

In many countries, especially developing countries preschool education is not fee-free and compulsory for all pupils. As a result, parents and guardians who cannot afford the fees do not bother to send their wards to preschool. The empirical investigation revealed that preschool education and experience have positive effects on pupils' competence at the start of formal education. Indeed, the children who attended preschool had lots of advantages over their friends who did not have the opportunity. This was evident in the confidence that those who had attended preschool exhibited during the interviewing process.

In this study we realised that the older children, who were eight years and over, did not attend preschool, and because they had not been exposed to more educative activities at home, they could not perform as much as their younger counterparts who had had formal preschool exposure. The preschool level predisposes pupils to activities and situations, which they are likely to encounter in formal school. Every child should therefore be given the opportunity to have the preschool experience that will prepare him or her for formal basic education.

The results of this study should serve as an impetus for various governments to review their policy on the attendance of pre-school if a more solid foundation at the basic level is to be achieved. It was realised that most pupils who did not attend preschool were from homes with poor backgrounds. Against this background, we suggested that governments, in their attempt to strengthen education at the basic level, should make preschool attendance both fee-free and compulsory so that every pupil entering formal school would have some refined skills as a foundation. Financial constraints in the home should not be a factor that should deprive children from having the preschool experience that will set the tone for them to face the formal school life ahead. Preschool education and care should therefore be taken more seriously if educational systems are to be built on a firm foundation.

Finally, the study brought to the fore that there were pupils who were five years old, and others who were over ten years old. It is therefore envisaged that teachers plan and deliver lessons with a fore knowledge of these backgrounds so that no pupil would be neglected. For teachers to serve each pupil's interest they should be aware of these competencies and experiences so that each pupil would be assisted with appropriate strategies to build on his or her previous knowledge.

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Do the Practices of Mathematics Teachers in Ghana Appear to Reflect the Same Values and Concerns as the Curriculum Standards?

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Abstract

The study sought to explore the relationship between implementation of curriculum standards in Mathematics and teachers' Classroom practice in Ghana Basic Education Certificate Examination (BECE). I used teacher questionnaire survey to find out whether the practices of mathematics teachers appear to reflect the same values and concerns as the curriculum standards. The finding that emerges from the study suggests that practices of teacher seemed not to reflect the values and concern entrenched in the curriculum standard. I have not been able to make any generalized claims from these finding in view of a small sample size studied. The finding, however, provide the fundamental data required for a large long-term study into the problem.

Introduction

Ghanaians increasingly hear about pupils who have gone through the basic educational system and are quite unhappy and uncomfortable with mathematics and regard it as a difficult subject in the curriculum. Also, parents, educational authorities and other stakeholders in education continually consider the current standards of mathematics education to be relatively low, and teachers are often blamed for such low standards. Consequently some schools, as a way of gaining public recognition, tend to engage in examination malpractices to help their pupils score higher marks in the national examinations. A case in point is the massive leakage of Mathematics and English papers of the BECE in May 2002 reported by Ghana Home Page (May, 2002). Many schools got access to these papers and the examination was totally cancelled.

In such circumstances, the question is whether teachers' classroom practices really meet the standards required by the curriculum. Do teachers teach for pupils' understanding of mathematics as prescribed by the curriculum or do they teach selectively for the purpose of getting pupils to pass examinations?

To promote equal opportunity efforts, an Act of Parliament was passed in 1994 in Ghana making basic education free and compulsory for all children of school-going age. The policy, popularly known as fCUBE (Free and Compulsory Universal Basic Education) highlighted the following issues in the teaching of mathematics:

- Drawing attention to the particular difficulties of teaching and learning mathematics;
- Observing the divide between modern and traditional mathematics arising from the changes since the 1960s;
- Giving emphasis to the effects of technological and changes through the increasing availability of calculators and strongly advocating their widespread use at all levels;
- Encouraging a greater awareness of the importance of mental calculation;
- Having a lot to say about teaching styles, emphasising discussion, practical work, investigative approaches and problem solving.

These measures were to improve the teaching of mathematics.

The mathematics curriculum standards

Let us consider what a curriculum is. A curriculum, for Howson *et al.* (1981, p.2), is clearly much more than a syllabus, and 'must encompass aims, content, methods and assessment procedures'. McCormick and James (1983) define curriculum in more pupil-centred terms as what is experienced by pupils when they are involved in learning activities and also as the outcome of learning in terms of the understandings, attitudes, etc. that pupils develop. Curriculum has also been defined as a plan for providing sets of learning opportunities for persons to be educated. Plans have no impact until they are set in motion; thus, learning opportunities remain only opportunities until learners become engaged with the opportunities. In my view, all these definitions have merit, but each is too limited. My definition incorporates everything suggested in all of them, including intentions, plans, assessment instruments, classroom teaching practices, pupil experiences and learning outcomes. The intent of this study is concerned with relationships among different elements of the curriculum, thus broadly defined.

The teacher, test and curriculum

There is the problem as to whether teachers teach according to what is generally spelt out in the curriculum or not. The teacher's role in the classroom has been found to be very crucial in the successful implementation of policies related to curriculum development and assessment. Torrance (1988) has, for example, noted that changes in assessment and especially public examinations impact most positively on curriculum and teaching methods, when teachers have an active role in the development process. He noted:

Crude changes in curriculum content and teaching methods can be instigated, but the quality of these changes will depend on teacher perceptions of their purpose and understandings of their broader curricular intentions (*ibid.*, p.155).

Thus we cannot talk about the effective use of testing in the classroom without thinking first about how practitioners actually understand the concept of testing and how they use it in the classroom. Available literature cited by Black and William (1988) suggests that teachers do not have an in-depth

understanding of what testing entails; neither do they use it well in the classroom. In a study conducted by Clune (1993) and Black (1993b.) for example, the following weaknesses were found to be very common in teachers' classroom testing approaches:

- classroom evaluation practices generally encourage superficial and rote learning, concentrating on recall of isolated details usually items of knowledge which pupils soon forget;
- teachers do not generally review the test questions that they use and do not discuss them critically with peers, so there is little reflection on what is being tested; and
- the grading function is over-emphasised and the learning function is under-emphasised and there is a tendency to use a normative rather than a criterion approach, which emphasises competition between pupils rather than personal improvement of each.

Methodology

I used questionnaire survey as an initial exploratory approach for this study. As Gay (1992) clearly explained, descriptive research survey involves the process of collecting data in order to test hypotheses or answer questions concerning the status of the object under study. Although surveys are sometimes viewed with suspicion by some who may doubt the truthfulness of the responses or are concerned about the sometimes low response rate, I was convinced of its relevance to my study, so I took steps to avoid these problems, and I recognised the limitations of what I could find in this way.

My position as an 'insider' to the Ghanaian education system has helped me throughout this study to utilise my 'pre-existing knowledge and experience based about the situation and the people involved' (Robson, 1993, p.447). Given the severe limits to my resources, I believe that in my choice of strategy I needed to place some tentative reliance on this pre-existing knowledge.

Identification of the population and sampling procedure

Ideally, I should have liked to understand the national picture, and so to have a representative sample from the population of all those teaching mathematics at this level in Ghanaian schools. However, as Denscombe (1998) argues, that can only satisfactorily be achieved through stratified random sampling from the national population of mathematics teachers or of schools. This is not possible at this stage considering limited financial conditions. Aside of this, the present study is a preparatory one and there is the aspiration for the larger study where this would be considered.

Three hundred teachers volunteered to participate in the study. The teachers came from each of the ten regions of Ghana. It is suggested (Kelly and Kanyika, 1999) that there are differences in educational provision and problems in different geographical areas as well as states and schools.

Administration of the Questionnaire

The questionnaire was distributed to the 300 teachers. With my colleague as the questionnaire administrator, and the head of the mathematics department as the co-ordinator for the in-service programme, a session of the programme period was devoted for the purpose of responding to the questionnaire.

Teacher Questionnaire Analysis

Since the research design for this study is mainly descriptive survey, the questionnaire, which is a useful instrument for collecting survey information has been used. The questionnaire covered 7 broad areas:- background information about both the teacher and his/her school, organising mathematics teaching, using the National Curriculum documents, using resources/classroom materials, covering the curriculum and reviewing work.

Respondents' Background information

Questionnaires were returned from 271 teachers, a 90 per cent response rate. The questionnaires returned show that 60 per cent of the respondents were teaching in both upper primary (Primary 4-Primary 6) and the JSS (JSS1-JSS3). The great majority of the respondents (65 per cent) teach in the JSS. The location and type of schools from which respondents came was mainly public schools in rural setup (46 per cent), with 24 per cent from public schools in urban area, 15 per cent from public schools in the city, 2 per cent from private schools in the city and also 2 per cent from private schools in urban area. One per cent was from the non-governmental schools in the rural location. About 1 per cent said they were teaching in private schools in the rural area.

The majority of the respondents were experience teachers – 50 per cent across all the levels had 2-5 years of teaching experience. One per cent had 1 year teaching experience, 25 per cent had taught for 5-10 years and 14 per cent had taught for more than 10 years. A little less than 1 per cent responded for having taught for less than a year. With this range of teaching experience, one might be tempted to conclude that there might be no problem in the implementation of the curriculum as far as the teachers' experiences are concerned.

The response to a question, which asked the respondents to indicate the level at which they studied maths as a main subject, revealed that 70 per cent of the respondent studied maths at the Teachers' Certificate level. Those who studied it at 'A' Level represented 15 per cent, and 3 per cent at Teachers' Diploma Level. One per cent each studied it at the B.ED and BSc/BA levels. From among the levels to be indicated, Teachers' Certificate 'A' and GCE 'A' Level are the least qualifications. It is noticed that the majority (70 per cent) of the teachers qualified with Teachers' Certificate which seems that the caliber of respondents for this study is least in terms of academic qualification in mathematics.

For question 10, 84 per cent of the respondents teach mainly mathematics and other subject(s) and 6 per cent teach only mathematics. Since a subject specialist tends to teach only that subject, and only 6 per cent teach only mathematics, it shows that specialists in mathematics in this study are very few. It seems therefore that, some mathematical concepts and their application might be a problem to this category of teachers.

Results

Questions 11-23 constitute questionnaire items intended for the teachers to indicate approach/es used by them to address issues of implementation.

The responses revealed that when teaching mathematics, a greater number of teachers does it using whole class. It is observed that 31 per cent used the

proportion of 51%-80% of the time to teach mathematics organising a whole class and 20 per cent does the same using the proportion of more than 80%. Ability/attainment groups reveal the contrary in the case of organising the teaching. In this case more teachers (31 per cent) used a proportion of time less than 5% and 11 per cent and 2 per cent used the proportion of time of 51%-80% respectively. Also, majority of the teachers used less than 5% proportion of time to organise their teaching by friendship groups (40 per cent) and on individual basis (30 percent). In organising by mixed ability groups, more teachers used the average proportion time of 5%-20% (26 per cent) and 21%-50% (22 per cent).

The result suggests that more teachers tend to teach mathematics by not considering the importance of the organisation by ability, mixed ability and friendship groups as well as the individuals. In line with this, the curriculum goals of the use of practical activities, development of problem-solving skills and facilitating discussion of mathematical ideas, may not be adequate for pupils' needs. In support of this claim, a report by Her Majesty's Inspectors (HMI, 1992) maintained that schools which introduce setting by ability, and organised classes that had full range of ability were exploring ways of matching work better to pupils' needs.

Another question asked teachers to indicate which documents they use for planning their lessons, and how often they use them. For the NC document, 10 per cent showed that they use it yearly, 14 per cent use it termly, 1 per cent use it half-termly. The majority (45 per cent) use it weekly and 15 per cent use it daily. Three per cent never use it. The general picture indicates that the NC document is being used on a higher average by the teachers. The rate at which the teachers use Teachers' Hand book is quite similar to the use of the NC document. Here, 34 per cent and 57 per cent daily use Teachers' Hand book and Pupils' books respectively. This shows that the constant use of these two documents is rather high.

A question required teachers to indicate how often they refer to areas (specific objectives, evaluation and teaching/learning activities) of the National Syllabus documents (NMS) in planning. Majority (47 per cent) refer to it weekly and 32 per cent refer to it daily, both in the case of specific objectives. For yearly, termly, half-termly and never, 2 per cent, 5 per cent, 3 per cent and 1 per cent respectively indicated referring to the National Mathematics Syllabus documents. Similar high rate of weekly and daily references to the NMS documents was indicated in the cases of evaluation and teaching/learning activities.

Question 16 was about how teachers describe from memory, what was in the different parts of the NC document in relation to examination syllabus. Relatively, low responses were indicated for 'Not at all' and high responses for 'Quite well'. Average responses were recorded for 'Well' and for 'A little'. The proportion of mathematics work teachers set which comes from teachers' handbook was asked in question 17. Majority (32 per cent) ticked 21%-50%, 22 per cent ticked 51%-80%, 16 per cent ticked 6%-20%, 9 per cent ticked 1%-5%, 5 per cent ticked 0%, and 4 per cent ticked >80%.

Teachers were asked to indicate the extent to which given documents are used when the teachers are preparing classroom activities. The response shows that majority (69 per cent) use a lot of their own ideas and a lot of NC document.

Question 19 asked the teachers to indicate what they mainly do for coverage of the curriculum. Twenty-five per cent indicated that they use information provided by the publisher of a scheme, 54 per cent said they use their own/school scheme of work and check any gaps, and 11 per cent indicated that they use other. How teachers record National Curriculum coverage was asked in question 20. Here, 31 per cent showed that they record it for individuals, 20 per cent for groups, and 37 per cent for the class.

Teachers were asked in question 21 to indicate how often they review their plans with the intention of developing or changing them. Fourteen per cent said daily, 43 per cent weekly, 12 per cent half termly and 19 per cent termly. Aspects of review of teachers' work were asked in question 22. The researcher requested the teachers to indicate whether specific statements apply to the areas of mathematics given them. The statements were given as follows: (1) "I have difficulty in implementing this area", (2) "My class does not work on this area every year", (3) "In most weeks my class works on this area" and (4) "In most terms my class works on this area". The areas of mathematics given were: Using and applying Mathematics (UAM), Number (Num), Measures (Meas), Algebra (Alg), Shape and Space (Sh & Sp), Handling Data (Hand.data) and Probability (Prob).

With difficulty in implementing an area, 24 per cent of the teachers pointed at Probability and 19 per cent indicated that theirs is the UAM. The next area that the teachers felt was a difficult one is Shape and Space. Here, the response rate was 17 per cent. Also 8 per cent, 7 per cent, 6 per cent and 3 per cent response rates were recorded for Measures, Handling Data, Algebra and Number respectively as being difficult areas.

Concerning an area for which a teacher does work on every year, majority (20 per cent) of the teachers said Probability and 18 per cent pointed at Shape and Space. Thirteen per cent mentioned UAM and the same percentage did for Handling Data. Algebra, Measures and Number were the areas not worked on by 8 per cent, 7 per cent and 6 per cent of the teachers respectively.

Most teachers (32 percent) mentioned Algebra as the area that their class works on in most weeks. Twenty-one per cent indicated Number, and each of Measures and Shape and Space were indicated by 9 per cent of the teachers. The responses also show that 7 per cent work on UAM in most weeks, 6 per cent on Handling Data and 2 per cent on Probability.

There appears to be some relationship established between responses for *difficulty in implementing an area* and *working in an area in most weeks*.

It would be noted that most of the teachers mentioned mostly Probability, UAM and Shape and Space as the areas they have difficulty in implementing, and fewer of them also indicated the same Probability, UAM and Shape and Space as areas their class work on most of the weeks. This suggests that most teachers tend to ignore the teaching of these areas most weeks as they are likely to face problems in their (areas) implementation.

The last statement, which the teachers should consider applicable to the given areas of mathematics, is: "In most terms my class works on this area".

Algebra is the area most teachers (26 per cent) work on in most terms. Seventeen per cent work on Number, while 12 per cent work on Shape and Space, and the response rate was 10 per cent each for UAM and Measure. The teachers indicated 9 per cent and 4 per cent for work in most terms on Handling Data and Probability respectively. Question 23 is one of the significant questionnaire items whose responses are most likely to address issues of implementation. The teachers were asked to indicate how (using more, using the same and using less) their approach to teaching mathematics has changed for practical work, problem solving, investigations, calculators, computers pencil/paper calculation and mental calculation. In addition, they were to say whether or not this change or otherwise was significantly influenced by the National Curriculum.

Out of the 90 per cent response rate (i.e. 271 responses), 48 per cent indicated that they *use more practical work* to teach mathematics, 20 per cent said they *use the same amount of practical work* and 15 per cent *use less practical work* in their approach to teaching mathematics. Seven per cent did not indicate any. With *problem solving*, 50 per cent *use more* while 25 per cent *use the same* and 8 per cent *use less*. Here again, 7 per cent did not say anything. In using the process of *investigations* to teach mathematics, 42 per cent indicated *using more*, 21 per cent *using the same*, and 20 per cent *using less*. Also, 7 per cent were silent.

As to whether the amount of *practical work* done was influenced by the national mathematics syllabus, 59 per cent responded in the affirmative and 20 per cent said no. Eleven per cent did not give any response. In the case of *problem solving*, 57 per cent was of the view that the amount carried out was as a result of the syllabus' influence, while 21 per cent was of the contrary opinion and 12 per cent abstained. The outcome of the syllabus being an influence to the approach to teaching mathematics using *investigations* was; 51 per cent said yes and 26 per cent said no and 13 per cent abstained. Apart from the areas of *use of calculators*, *computers* and *mental calculation*, where 51 per cent, 60 per cent and 43 percent respectively disagreed that the extent of usage was as a result of the influence of the syllabus, 43 per cent agreed that there was an influence in their use of pencil/paper calculation.

Issues emerging and findings from the data

As has already been mentioned, the analysis of the questionnaire data is mainly concentrated on organizing mathematics teaching (questions 11-13), and reviewing work (questions 22-23). Responses to question 11 revealed that the teachers organise mathematics teaching using mainly a larger or whole group of pupils, this, perhaps to the detriment of using smaller, or ability, or mixed ability groups. When these responses were matched with responses to question 12 (description of how teachers allocate work to children) and question 13 (how often teachers plan for various sets of pupils), it was clear that, there was some salient association between it and the response of question 11, for, responses to question 11 show that most of the teachers assigned same work to children at

the same pace, which as I opined, suggests teaching the children in a whole or larger group.

Conclusion

In answering the questionnaire, the teachers revealed that in some respects their practices do not appear to reflect the same values and concerns as the curriculum standards. The study provided an indication that teachers' perceptions were that their difficulties lay in three main areas: Problem-solving, Using and Applying Mathematics and Probability. This revelation poses a real danger in the sense that problem-solving is the heart of what mathematics is about. Presented in the right way, many mathematical ideas can be introduced by starting with a problem for pupils to investigate. Such an approach can draw out, build on and consolidate key ideas, provide a foundation and motivation for developing understanding and encourage further application of ideas in a variety of ways. Using and Applying Mathematics is also widely seen as critical to the meaningfulness of mathematics to learners as well as to its usefulness as a key subject in the school curriculum.

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A Comparison of Two Methods of Compound Subtraction: Decomposition and Base-Complement Addition

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Abstract

The 4-week study investigated which of two methods of Compound Subtraction, 'Decomposition': (DEC, a conventional algorithm) or 'Base-complement Addition' (BCA, a non-conventional algorithm), effected a better change in two randomised groups of 36 primary three subjects (BCA-17, DEC-19) on the measures of *accuracy*, *understanding*, *retention* and *speed*, involving whole numbers. The subjects were selected from the then seven existing primary schools (6 public, 1 private) all at Breman Asikuma in the Central Region of Ghana. The t-distribution, involving the difference between means, was used to analyse the results of subjects on the measures of *accuracy*, *understanding* and *retention* while the *median test* was used in analysing the *speed tests*, all at the 0.05 level of significance. The study revealed some inherent potentialities for the BCA algorithm and could be implemented side by side with the DEC algorithm. It is also anticipated educational planners, curriculum developers and Mathematical Associations of the sub-region could access the BCA algorithm for its large-scale use. Among recommendations made was the need to embark on a large-scale comparative study using subjects without fore-knowledge of the DEC algorithm. None of the results was significant in favour of either the DEC or BCA algorithm on all four measures.

Introduction

A major aspiration of any developing country is the desire to build an academically strong, united, prosperous and economically vibrant society. The desire for economic viability depends on industrialization the basis of which is Science and Technology. Science and Technology, by far and large, also depend on the indispensable tools of Mathematics. Mathematics on the school curriculum, perhaps, is appreciated from the standpoint of its utilitarian value. The need for this utilitarian value depends, to a large extent, on the framework of its computation. Among the framework of basic mathematical computations is the topic subtraction, viewed as one of the most useful topics in social mathematics (Gyening, 1993). Among the uses of subtraction are the following:

- in buying services invariably we are not able to give the exact amount for the price; the need for a change, therefore involves subtraction;
- sorting out the good part of our farm produce for storage involves subtraction;
- in applied mathematics, subtraction finds uses under probability; for example to evaluate the probability of two or more events, one can find the probabilities of zero and one, add these together and subtract from one; the area between two curves as implemented under integration more or less, employs the concept of subtraction.

In spite of the diverse uses of subtraction it looks as if the topic has been creating uneasiness for both the teacher and the learner where the focus is on regrouping (Porter, 1961, Grossnickel and Brueckner 1963; Seville 1964). It looks like the three conventional algorithms in use for implementing compound subtraction worldwide are the Decomposition, the Equal Additions and the Austrian Method. As a result of the vexatious nature of the topic of subtraction (Porter, 1961), Suydam et al (1978) assert that there have been studies of late, involving the development of algorithms for compound subtraction in which a minimum of memory is required. Some of the non-conventional methods are:

- place after place re-naming of the minuend (Hutchings, 1975);
- the complementary method of subtraction (Spitzer, 1967);
- subtraction with Marked-out-Reference points (Kennedy and Tipps, 1985);
- the Reisman Computation Board (Reisman, 1977);
- ‘subtraction without Borrowing’ (Colton 1980);
- A ‘No-Borrowing’ subtraction algorithm (Brown, 1982); and
- the Base-Complement Addition method (Gyening, 1993).

Though some of the non-conventional methods are appealing the following observations cannot go unnoticed:

- Some of the algorithms use the crutch technique, thus demeaning the place value concept;
- the complementary method looks interesting but does not look elegant enough;
- Reisman Computation Board is quite interesting but puts cognitive strain on the learner;
- Colton’s ‘Subtraction without Borrowing’ after all involves some borrowing;
- Brown’s ‘No-borrowing’ subtraction algorithm is a nice mathematical show piece but steps involved in teaching it are time consuming.

The Base-Complement Addition Method is a modified form of the Equal Additions Method (EA). As a variant of the EA method, the BCA is still based on the principle of compensation. The rationale of the BCA algorithm is to transform a given compound subtraction by adding the complement whole number, of any base to both the minuend and subtrahend, where an impasse occurs. For example, in base ten

$$\begin{array}{r} 42 \\ -27 \\ \hline \end{array} \text{ will transform to } \begin{array}{r} 45 \\ -30 \\ \hline \end{array}$$

before subtraction is effected. Here because the complement of 7, where the impasse occurs, in Base Ten is 3, three was added as follows:

$$\begin{array}{r} 42 \\ -27 \\ \hline \end{array} \xrightarrow[\text{to minuend and subtrahend}]{\text{add 3}} \begin{array}{r} 45 \\ -30 \\ \hline 15 \end{array}$$

The potentiality of the BCA method was recognized and recommended by Armar and Brown (1971), Byrkit (1988) and lately by Gyening (1993).

Under the decomposition algorithm the 42 would have the minuend, 42, decomposed as

$$\begin{array}{r} 3 \text{ tens} \quad 12 \text{ ones} \\ -2 \text{ tens} \quad 7 \text{ ones} \\ \hline \end{array} \quad \text{resulting in} \quad \begin{array}{r} 1 \quad 5 \\ \hline \end{array} \quad \text{or using the crutch strategy}$$

$$\begin{array}{r} 42 \\ -27 \\ \hline 15 \\ \hline \hline \end{array}$$

Under the EA algorithm,

$$\begin{array}{r} 42 \text{ is implemented as follows: } 4^1 2 \\ -27 \quad \quad \quad -37 \\ \hline 15 \\ \hline \hline \end{array}$$

The transformation of 2 to 12 is compensated by adding 1 ten to the tens column of the subtrahend

Gyening (1993) asserts even though the EA method induces speed, deals effectively with zero in the minuend and ensures accuracy in computation it cannot be objectified. The decomposition is a more preferred algorithm because of its ability to demonstrate the re-grouping method and that it can be rationalised and generalised beyond whole numbers to mixed or denominate numbers (Thorndike, 1921). Its drawbacks include:

- its inability to deal with zero in the minuend (Kennedy and Tipps, 1988);
- the use of crutch by this algorithm does not only make work untidy but also demeans the place-value concept (Gyening, 1993);

Gyening (1993) also observed that apart from putting extra cognitive strain on the learner both conventional algorithms are prone to reversal errors. The use of the DEC is also, considered time consuming.

It was to offset these demerits associated with both conventional algorithms for implementing the topic of subtraction that the need arose to evolve an algorithm that would place less strain on both the learner and the teacher.

In spite of the respective merits claimed by advocates of the two conventional methods for implementing compound subtraction (DEC and EA) findings from previous studies are stated below:

- Carpenter et al (1975) relying on records of responses of pupils in the National Assessment of Educational Progress (NAEP, 1972-75), Mathematics Assessment, observed that 45 percent of the nine-year olds could not compute a two-digit subtraction exercises involving re-grouping.
- In another development, Kouba et al (1988) relying on records of the fourth NAEP, Mathematics Assessment, observed that 50 per cent of the third graders, 15 per cent of the seventh graders and 9 per cent of the eleventh graders could not compute a three-digit subtraction problem with regrouping.

Ghana recommends the use of the decomposition algorithm in its schools. This fact is buttressed by the recommended method of subtraction in the primary school mathematics syllabus, teacher's handbooks and the textbooks in use at this level. In theory subtraction is the last topic in primary one but in practice the topic takes off in primary two (Ghana Education Service, 1988). Despite this early start, there is evidence of poor performance of pupils on subtraction items involving regrouping in primary six. Results from the report of the Primary Education Programme (Ghana Ministry of Education, 1993) on the Criterion Referenced Tests revealed the following:

- only 1.1 per cent of pupils in primary six achieved over 50 per cent pass.
- Almost 40 per cent of the candidates on this test could not answer subtraction questions with regrouping involving two-digit numbers.

A spill-over effect of such deficiencies has been identified on both the Ordinary Level and Senior Secondary School Certificate Examinations (West African Examination

Council, 1992, 1993). Further evidence has it that subsequent criterion referenced tests have not produced good results as yet. With the mastery level of 55 per cent for Mathematics, percentage passes were 1.5 and 1.8 for 1994 and 1996 respectively (Amoako-Nuamah, 1997).

Statement of the Problem

Studies on the relative merits of the Decomposition and Equal Additions algorithms have yielded inconclusive results. Evidence suggest that pupils are yet to cope with two and three-digit compound subtraction exercises (Carpenter et al, 1975; Kouba et al 1988; Ghana Ministry of Education, 1993). These uneasiness could perhaps be traced to some common inherent problems associated with the two conventional algorithms (Gyening, 1993). There is therefore the need to search for a non-conventional method that will prove more reliable, more accurate and easier for the learner to learn and use. Gyening (1993) found that by removing the structural problems in EA and therefore transforming it to BCA, the transformed EA (BCA) can be made more effective than the DEC. For example, in 62

-49

while the DEC method would regroup the minuend as 5 tens and 12 ones before 4 tens and 9 ones are subtracted from the minuend, the BCA would add the complement of 9 in base ten, 1, to both the minuend and subtrahend before effecting the subtraction. Thus for

$$\begin{array}{ccc} 62 & \xrightarrow{\text{Add 1}} & 63 \\ -49 & & -50; \end{array}$$

the structural changes help readily to find the difference as 13. Since results emanating from DEC and EA studies could be likened to the opening of a pandora's box and that students are found wanting when it comes to using either of the conventional algorithms for compound subtraction the need arises to probe beyond the conventional outfit to evolve a more handy algorithm for the pupil to learn and use. It was in the light of the seeming stalemate that the study was carried out so as to compare the two methods (DEC and BCA) of subtraction of whole numbers on the measures of accuracy, understanding retention and speed.

- Accuracy – the mean score on the posttest
- Understanding – this was synonymous with transferability. The ability to transfer, or demonstrate successful carry-over to untaught process (Brownell and Moser, 1949). Transfer was measured in this study by ability to solve ten 4 – digit compound subtraction problems after receiving instruction involving 2 and 3 – digit examples.
- Retention – Test items were a parallel of the posttest. A period of 21 days during which each of the two groups worked on their own on different topics (further addition) in sub-groups under the supervision of group leaders. The mean scores were used in testing the hypothesis on retention.

- Speed – this was the ratio of time taken to complete work to the total of correct responses on the post-test and retention test, since the investigator was not interested in the early finishing of the test items alone because often the fastest child may compute quickly but incorrectly (Martins, 1992). Johnson's (1938) variable time was used to determine the finishing times of subjects.

Research Questions

The study was designed to answer the following five questions: Which group will

- make fewer errors on compound subtraction problems (accuracy);
- be able to transfer the related skill better (understanding);
- be able to remember the related skill better, (retention);
- Complete compound subtraction tasks faster on the post-test (speed);
- Complete compound subtraction tasks faster on the retention test (speed)

Is it those taught by Decomposition or those taught by the Base-Complement Addition Method?

Corresponding to the foregoing research questions five hypotheses were specified for testing at the 0.05 level of significance.

- there is no significant difference in accuracy between the mean scores of the DEC and BCA groups on the post-test;
- there's no significant difference between the mean scores of the DEC and BCA groups on the test of understanding;
- the mean scores of the DEC and BCA groups on the retention test are not significantly different;
- the median finishing time of the subjects of the DEC group will not be significantly greater than that of the BCA group;
- the median finishing time of the subject of the DEC group will not be significantly greater than that of BCA group on the retention test.

Methodology

Population and Sample

While the target population was all primary three pupils of Breman Asikuma Education District, Central Region, Ghana, the accessible population was all primary three pupils selected for the study from all the 7 schools (6 public; 1 private). Subjects were saddled with problems of absenteeism, lateness to school, lack of mathematics textbooks and improper use of spare time. Each of the 7 schools, except one, had 10 subjects randomly selected for the study. One of the schools (Catholic Girls' School) had 20 subjects because research has shown that there is no gender difference in mathematical ability at the primary three level

(Fennema and Sherman, 1977). The first meeting had a sample size of 64 (25 boys and 39 girls) with a mean age of 9.71 and standard deviation of 1.07. While the DEC group had a mean age of 9.66 and standard deviation of 0.87 the BCA group had a mean age of 9.7 with standard deviation of 1.24. Ages of subjects ranged from 8-13 years. Subjects had varied socio-economic background but were predominantly rural. Some subjects ran errands, during their spare time for a fee and took delight in viewing television programmes (concerts and opera). Subjects had studied and implemented the DEC algorithm for two academic years before the study was conducted. The simple random technique was used in selecting subjects. This was done in three phases:

- List of subjects compiled for each school. Name of each girl participant written on a strip of paper, folded put into an empty box, shuffled and selected one at a time without replacement by respective class teachers. Only the first five names selected took part in the study (same process done for boy-participants).
- Names of all boys constituted one group with all girls constituting another group. Same selection process in (1) was followed using the research assistant. All odd ordinal selections for both boys and girls formed one group while all even ordinal sections also formed the next group.
- A representative from each group, chosen by consensus, engaged in die throwing. The first representative that threw a six selected a cube from a box containing a blue and a green cube, each covered with cement paper. While Blue stood for DEC, Green signified BCA.

Design

The pretest-post-test comparative group design was used for the study.

Instrument

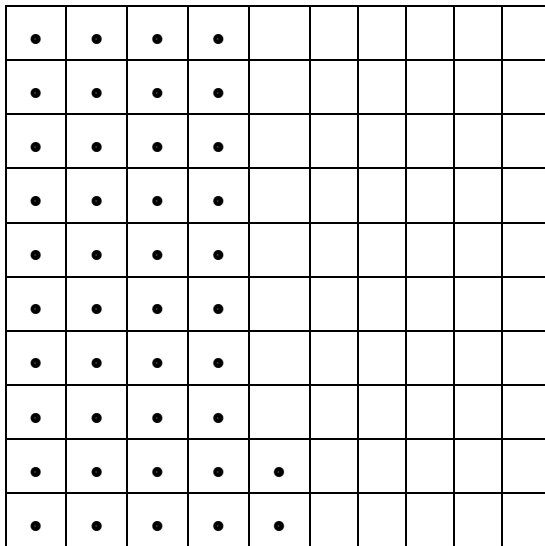
Teacher prepared achievement test (Pretest – 20 items; posttest – 20 items; test of understanding – 10 items; Retention – 20 items; was a parallel of the posttest) were used for the study. Test items were scrutinized by a few mathematics educators for advice, and suggestions. Test items were piloted in two schools in the same Education District, so as to ensure both the content and face-validity of the instruments. Since scoring was to be done dichotomously, Kuder Richardson's formula - 21 was used to compute the reliability coefficients of all the achievement tests. The reliability coefficients were 0.82, 0.88, 0.77 and 0.87 for the pretest, posttest, test of understanding and the retention test respectively.

Research Procedure

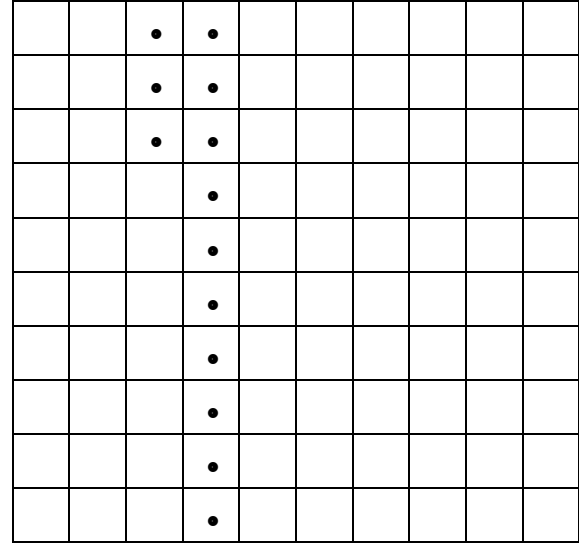
- Permission was sought from the District Director of Education to use the schools for the study;
- research took off four days after the third term break;

- initial visits had been made to the schools for the study during which the headteachers, class teachers and the target population were met and briefed on the rationale of the study;
- subjects that were not to travel during the holidays were to take permission from parents to take part in the study.
- subjects selected were given letters to parents not to give any form of academic help at home, in Mathematics, for the period of the study (4 weeks).
- research assistant was given orientation as follows.
 - occupy the unused class, allowing subjects to work on their own;
 - to mark scripts of subjects that completed work serially and to see to it that subjects left the classroom quietly to allow others to complete work;
 - subject completing any of the achievement test put up the unused hand to help record finishing time.
- instructional programme developed for each group was sequenced and implemented in 20 lessons;
- a pre-test was administered prior to the treatment period (2 and 3-digit subtraction and addition without regrouping and about 5 items on 2 and 3-digit subtraction with regrouping);
- each subject had a copy of the group test item boldly hand written by researcher using carbon paper. Answers were to be provided on the same question paper;
- prior to the pretest subjects were invited one after the other for interview to help ascertain the respective demographic details with the researcher and research assistant focusing on the BCA and DEC groups respectively;
- both groups took each test at the same time;
- Johnson's (1938) variable time was used to record the finishing time of each subject. It was from this data that the respective median finishing times and the common median finishing times were determined;
- "above" and "below" as used in the study meant subjects finishing work after and before the common median finishing times respectively;
- scoring was done dichotomously that is one point was awarded for each correct item or one was scored zero.
- While the spikes abacus was used in implementing the DEC algorithm, the grid-board with marbles was used to implement the BCA algorithm.

Fig. 1: Demonstrating 42–27 using the square–grid board and marbles.



(b)

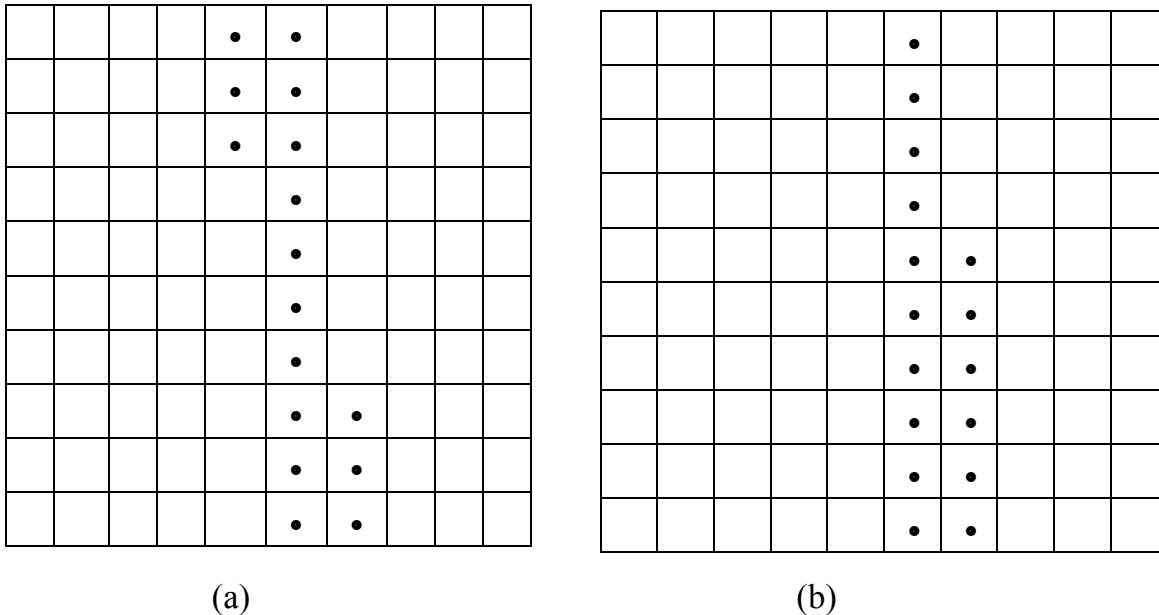


(a)

- 42 marbles are arranged always starting from the bottom of the column/block on the extreme left/see fig 1(a);
- after filling the first column, the child moves to the next column, to the right, and continues to fill, always starting from the bottom upward while child continues to count until 42 is reached (fig 1(a))
- the child counts out 27 marbles from the 42 by removing 27 marbles, while counting, following the same order – always starting from the bottom of the first block on the extreme left up to the top of the column followed by the bottom of the second block up to its topmost space etc.
- the final diagram is as shown in fig 1(b)
- counting the remaining marbles, leaves 15 thus

$$\begin{array}{r}
 42 \\
 -27 \\
 \hline
 15 \\
 \hline
 \end{array}$$

Fig 2: Transforming 2-digit compound subtraction exercise (63-47) to simple subtraction (66-50).



- the child through examples and exercises sees fig 2(a) as representing 63-47 (47 marbles removed from 63);
- this skill is really necessary to help write out the transformed form of any given compound subtraction exercise;
- next, the remaining 3 marbles in the fifth column/block (reckoning from the extreme left) of fig 2(a) are removed and added on to the 63 to make 66 as shown in fig 2(b)
- since the empty spaces of fig 2(b) are 50 the transformed form of

$$\begin{array}{rcl}
 63 & \text{results in} & 66 \\
 \underline{-47} & & \underline{-50} \\
 & & \underline{16}
 \end{array}$$

Analysis of Data

The mean and standard deviation were computed for each test, the median finishing times were also determined for each group on the pretest, post-test and the retention test. In addition, the common median finishing time was computed for each test. To justify the use of the t-test, involving the method of pooled variances, the pretest group variances were put to the F-maximum test (Homogeneity of variances) and this satisfied the criterion

for equality of variances. The F-ratio of 1.34 was less than the F-critical of 1.84 at the 0.05 level of significance. In sum, the measures of accuracy, understanding and retention were analysed using the method of pooled variances.

The speed tests were analysed using the median test. What the median test does is to show whether two groups (not necessarily of the same size) differ in central tendencies. In other words, whether or not the two groups were drawn from populations with the same median. The median test employs the chi-square statistic, for independent samples, with one degree of freedom. The use of the median test was justified because $N = 36$ (that is between 20 and 40) with each cell of the 2×2 contingency table giving expected frequency above 5 Cochran (1954) (as cited in Sidney, 1956). In the use of the two test-statistic the null hypothesis was accepted if $\chi\text{-computed} < \chi\text{-critical}$ or of $p\text{-value (computed)} > p\text{-value (critical)}$

The 'effective subsample' concept disregarded any subject that made less than 40 per cent mark on either the pretest or an average mark of 40 percent on both the pretest and post-test. This concept and the experimental mortality reduced the sample size from the post-test stage to 36 subjects (BCA – 17, DEC – 19).

Results

Table 1 The Mean (x), Standard Deviations (s) and t-values of the Pretest-Scores

Group	X	S	N	t-computed	t-critical
BCA		10.38	5.11	32	0.89
DEC		11.44	4.42	32	2.0
				↓	↓
				$P=0.38 \therefore P>0.05$	

Table 2: The Mean (x), Standard Deviations (s) and t-values for the Post-test Scores

Group	X	S	N	t-computed	t-critical
BCA		16.29	3.64	17	1.23
DEC		14.37	5.43	19	2.03
				↓	↓
				$P=0.23 \therefore P>0.05$	

Table 3 The Mean (x), Standard Deviations (s) and t-values of the Test of Understanding

Group	X	S	N	t-computed	t-critical
BCA	7.6	1.89	17	1.53	2.03
DEC	5.68	3.23	19		
				↓	↓
				P=0.59 ∴ P>0.05	

Table 4 The Mean (x), Standard Deviations (s) and t-values of the Retention Test Scores

Group	X	S	N	t-computed	t-critical
BCA	15.94	3.56	7	0.55	2.03
DEC	15.11	5.33	19		
				↓	↓
				P=0.13 ∴ P>0.05	

Table 5 A contingency Table showing Frequencies Above and Below the Common Median Time for the Pretest

	BCA	DEC	Total
Above	20	12	32
Below	12	20	32
Total	32	32	64

Table 6 A contingency Table showing Frequencies Above and Below the Common Median Time for the Post-test and the Retention Test

	BCA	DEC	Total
Above	9	9	18
Below	8	10	18
Total	17	19	36

Table 7 The Median Finishing Times Corresponding Chi-square and p-values of the Common Median Finishing Times of the Pretest Speed

	Median Finishing Time (Min. & Sec.)		Common Median Finishing Time (Min. & Sec.)	Computed	Chi-Square Critical	
	BCA	DCE				p
Pretest	15:15	11:45	13:58	p ↓ 3.06	0.08	p ↓ 3.84
	0.05					

Table 8

The Median Finishing Times Corresponding Chi-square and p-values of the Common Median Finishing Time for the Post-test and the Retention Speed Tests.

Instrument	Median Finishing		Common Median	Chi square		
	Time (Min. & Sec.)		Finishing Time			
			(Min. & Sec.)	Computed	Critical	
	BCA	DEC				
Post-test	20:15	16:15	15:45	3.06 (p=0.08)	3.84	(p=0.05)
(Speed)	1.13	0.90	0.93	0 (p=0.498)	3.84	(p=0.05)
Retention test	16:15	9:15	17:15			
(Speed)	1.02	0.84	0.91	0 (p=0.498)	3.84	(p=0.05)

Table 1 presents the mean, standard deviation and sample size of the DEC and BCA groups. Subjects were not conversant with regrouping with regard to both addition and subtraction. The implication from table 1 is that before the treatment there was no significant difference in the mean scores of the two groups on the measure of accuracy; additionally it could be said that the randomization process was fair.

Table 2 gives data on the post-test scores. While the results of the BCA group ranged from 6 to 20 that of the DEC grouped ranged from 2 to 20. At the effective subsample mark of 40 per cent or more, 94 per cent of the BCA group made this while 84 per cent of the DEC subjects achieved the mark. Using the PREP 55 per cent mastery level 94 percent of the BCA subjects made the mark while 79 per cent of the DEC group made the mark.

Table 3 is on the test of understanding. The BCA group achieved higher percentage gains on all the items. At the 40 percent effective subsample mark, 100 percent of the BCA group achieved this while 68 percent of the DEC made the mark. At the 55 percent mastery level, while 76.5 percent of the BCA group made the mark, 42.6 percent of the DEC group achieved the mark. Generally, the achievement of the BCA group proved higher.

Table 4 on the retention test considered, while 100 percent of the BCA subjects made the effective subsample mark, 89 percent of the DEC respondents obtained the mark. At the mastery level of 55 percent while 94 percent of the BCA group achieved this 83 per cent of the DEC group met the criterion.

Tables 5 and 6, on the speed test, specify how subjects were cast on the contingency tables for pretest and post-test and retention test respectively.

Tables 7 and 8 deal with the median finishing times, corresponding chi square and p values of the common median finishing times of the pretest on one hand and the post-test and retention speeds on the other. In all the test none of the results proved significant in favour of any of the two groups.

Discussion of Results

The Base-Complement Addition Method has attracted a few studies vis-à-vis the Decomposition Method (Gyening, 1993; McCarthy 1994; Baaba Quarcoo, 1995; Boateng 1996; Loh, 1996; Tamakloe, 1996 and Atidigah 1996). Except in the case of a few studies (McCarthy, 1994; Kissiedu, 1997; Abaidoo-Ayin and Kpakpa Quartey, 1998), most of these studies showed significant results

in favour of the BCA algorithm on the measures of accuracy, retention and speed. However, in almost all these studies the speed tests did not relate how quickly one completed the test item to one's score. Understanding as a measure was ignored by almost all the studies cited. This, however, was not good enough in view of the meaning theory in vogue. The DEC group had a headstart in many areas. Among these advantages were:

- the availability of textbook for the DEC algorithm;
- the exposure of the DEC algorithm to both groups for over two years before the study was carried out;
- the high incidence of experimental mortality on the part of the BCA group (BCA-21.9, DEC-15.6 per cent)
- the compelling problem of the BCA group to unlearn the internalized DEC algorithm in order to learn the BCA algorithm;

In spite of the advantages the DEC group had, this group could not outperform the BCA group on the measures of accuracy, understanding and retention (see tables). On the speed test, neither the DEC nor the BCA group proved significantly faster. The accuracy and retention results of the study confirm the findings of the following DEC-BCA studies (McCarthy, 1994; Abaidoo-Ayin and Kpakpa-Quartey, 1998; Kissiedu, 1997 and Boateng, 1996), that had non-significant results. The insignificant understanding result also confirms Kissiedu's (1997) study. On-speed, the study confirmed the insignificant result of Loh (1996) and others (Abaidoo-Ayin and Kpakpa Quartey, 1998; Kissiedu, 1997).

Conclusions

Based on the results of the study the following conclusions could be drawn:

- the mean score of the BCA group was higher than that of the DEC group on the measure of accuracy but the difference was not significant;
- when transfer means between the treatment groups were compared, no significant difference was found even though the BCA group mean was higher;
- there was no significant difference between the mean scores of the two groups on the measure of retention, despite the higher mean score of the BCA group. On the speed test involving posttest items, the median finishing time of the DEC group differed from that of the BCA group by 13.8 seconds in favour of the DEC group, however, statistical test found this to be approximately the same since the median finishing times were not significantly different;
- on the speed test involving retention items, the median finishing time of the DEC group differed from that of the BCA group by 10.8 seconds in favour of the DEC group. This statistically, was found to be not significantly different.

Recommendations

Based on the findings of the study, the following recommendations were made.

- that the BCA algorithm could be incorporated into the mainstream of the primary school mathematics syllabus to run side by side with the DEC algorithm;
- that the potentiality of the BCA algorithm calls for the need to include it in the syllabuses for pre-service and courses for in-service training of teachers;
- that seminars, symposia, workshops and conferences be organized to highlight the potentiality of the BCA algorithm so as to draw the attention of policy makers, curriculum developers as well as Mathematical Associations of the West African sub-region in general and Ghana in particular;
- that a further research involving the DEC and BCA algorithms be undertaken at different levels and on a larger scale so as to help generalize findings;
- in view of the experimental mortality the study suffered, where two or more schools are involved regular school hours should be used for the study;
- to help prove the potentiality of the BCA method, a comparative study of the two algorithms be conducted using groups without fore-knowledge of the DEC algorithm.
- now that EA can be objectified (BCA) a comparative study of EA and BCA could be investigated on all the measures of this study.

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